Towards the Excellence in Research, Education, and Service

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Overview

This document summarizes my primary efforts and main contributions as well as highlights my major accomplishments during the last ten years towards the excellence in all professional aspects of my academic career including **research, education, human resource development, and university, community, and professional services**. In particular, this document comprises the following sections:

- **Research Grants, Honors, and Awards;**
- **Research Contributions and Project Summary;**
- **Industrial Collaborations;**
- **Course Teaching;**
- **Curriculum Innovation and Development;**
- **Interdisciplinary Activities;**
- **Graduate Advising and Human Resource Development;** and
- **University, Public, and Professional services.**

The more detailed items with additional information about my academic activities have been documented in the attached curriculum vitae.

Research Grants, Honors, and Awards

This section and the next two sections outline my research activities and primary research achievements in several important aspects including:

1. **Research Funding,**

2. **Honors and Awards,**

3. **Research Contributions,** and

4. **Industrial Collaborations.**

From the very start of my academic career, I have been working extremely diligently to write research grant proposals and submit them to national and local funding agencies, in order to attract external funds from different sources and initiate independent research. Consequently, during the last ten years, as a principal investigator (PI) I have successfully won many research awards which are worth more than three million U.S. dollars in their total value. Through research funding, I have been contributing significantly to the R&D efforts and research objectives of both the Computer Science (CS) department and State University of New York at Stony Brook (SUNYSB), improving their research resources, and increasing their national and international visibility. Among all the research grants I have received during the last ten years, I would like to highlight the following most-recognized awards:

- The very prestigious **NSF CAREER Award** for top-quality young faculty members in the nation (1997);

- **Two awards** from the extremely-competitive **NSF Information Technology Research (ITR) Program** (**one small ITR grant in 2000, and one medium ITR grant in 2003**);

- The newly-established, highly-competitive, annual **Honda Initiation Award** from Honda America (2000); and

- **Alfred P. Sloan Research Fellowship (2001-2003)**.

It may be noted that the NSF ITR initiative had routinely received more than 1000 proposals each year from all the top research universities during its five-year existence (2000-2004) in the U.S. So, the competition had been extremely high with a very low successful rate. Because of the significance of our work, I have been fortunate to receive two ITR grants during the past five years (please refer to http://www.itr.nsf.gov for the details). For the Honda Initiation Award, since 1997 typically ten awards have been made throughout the U.S. each year, selected from more than one hundred research proposals every year. In December 2000, I received the Honda Initiation Award from Honda America (please refer to http://research.honda.com for the details). In April 2001, I was one out of the ten Computer Science recipients who were awarded 2001 Sloan Research Fellowship. Together with my NSF CAREER Award, the aforementioned awards have greatly promoted my own research status, and at the same time have enhanced the visibility of both CS department and the university in our research communities.

Besides national funding agencies, I have also been actively seeking research supports from both relevant state programs and (local and national) industry. For example, in 2000 I received two SPIR grants through the sponsorship of Robocom Systems International, a local company on Long Island. In 1997 and 1998, Ford Motor Company donated $37,500 as a cash gift to our Stony Brook Foundation to match and support my NSF CAREER Award. In 2000, I also received a software donation from Structural Dynamics Research Corporation (SDRC), one of the leading CAD software companies. The total cash value of SDRC's software donation to our SUNYSB research community is worth more than $3,000,000.

In April 2000, I presented a research seminar at the newly-established Center for Data Intensive Computing (CDIC) in Brookhaven National Laboratory (BNL). Soon after that, I also received a research appointment at BNL-CDIC directed by Professor James Glimm. These efforts promise to provide me many more opportunities to further attract research funding and forge ahead for new research collaborations for various initiatives from BNL, relevant national laboratories, DOE, and other national agencies. As a result of these efforts, I had secured two small grants from Brookhaven National Laboratory in 2000-2002 as the PI:

- "Parallel Software Development for BNL Aerosol Chemical Transport and Transformation Model," Brookhaven National Laboratory, $27,062, November 2001 to October 2002; and
- "Parallel Computation Techniques and System Development for Chemical Transport Modeling and Simulation," Brookhaven National Laboratory, $15,432, May 2001 to November 2001.

In addition, I was also participating in the research activities of the Sensor CAT of New York State ("Novel Engineering Design Techniques for the Next-Generation, Integrated CAE/CAD/CIM in Automobile Industry," Sensor CAT of New York State, $8,000, January 2001 to December 2001). The detailed funding information of my research grants and awards has been itemized in the attached curriculum vitae.

Research Contributions and Project Summary

This section presents my research contributions, outlines my research interests, and summarizes my previous and on-going research projects.

In addition to my strong track record in attracting external research funding, I also strive to improve my research through extensive paper publication in top-quality international conferences and world-class journals. I shall summarize the current and prior research activities of my research group (including my students and myself). Please refer to the accompanying curriculum vitae for the detailed publication record. My research interests fall into the general areas of visual computing. Major fields of my expertise include

- **Computer Graphics**,
- **Shape Modeling and Geometric Design**,
- **Physics-based Modeling and Simulation**,
- **Computer Aided Design and Manufacturing (CAD/CAM)**,
- **Scientific Computing and Visualization**,
- **Animation and Human-Computer Interaction**, and
- **Virtual Environments**.

One key contribution of my research to the scientific communities is that I have proposed and developed a novel deformable modeling and design methodology: **the new physics-based deformable modeling and design paradigm for visual computing**. The physics-based modeling and design approach we proposed, formulated, and developed during the last ten years can integrate geometric objects with physical and material properties and allow modeling and design requirements to be expressed and satisfied through the use of energies, forces, constraints, etc. Sculpting tools are implemented as applied forces. Certain aesthetic constraints such as "fairness" are expressible in terms of elastic energies. I shall first summarize several major research contributions in physics-based modeling and design made during the last several years as follows:

- We have developed an arsenal of meaningful sculpting tools that can expedite the direct manipulation and interactive sculpting of free-form geometric objects (including curves, surfaces, and solids) [92, 91, 10, 9, 8];
- We have formulated Dynamic NURBS (D-NURBS), which are a physics-based generalization of industry-standard geometric NURBS [92, 89, 93];
- We have pioneered Hierarchical D-NURBS [108];
- We have devised efficient algorithms for the automatic determination of unknown D-NURBS knot vectors [103, 104, 105];
- We have developed several dynamic generalizations of subdivision surfaces based on the Catmull-Clark scheme [91, 71, 70, 76, 72], Butterfly schemes [73, 75, 72, 67, 66, 74], and subdivision wavelets [68, 69]; and

- We have formulated an FEM-based subdivision surface within our physics-based modeling framework [72, 67, 74, 90]. The new FEM formulations are based on Catmull-Clark subdivision, Butterfly subdivision, and Loop subdivision in a unified way, and they can be further generalized to arbitrary subdivision schemes in a systematic fashion.

These new dynamic models, based on the concepts of recursive subdivision and multi-resolution analysis, combine the benefits of procedure-based surfaces for modeling arbitrary topology as well as the dynamic splines for direct and interactive manipulation of shapes by applying simulated forces. All of the aforementioned dynamic models allow designers to specify one or many point attractors that pull the geometric object via spring forces. In addition, these new models can synthesize image-based forces to automatically reconstruct shapes from volumetric image data. Our on-going research activities indicate a promising future for physics-based modeling in a large variety of scientific and engineering applications such as computer-aided design, computer graphics, human-computer interaction, finite element analysis, reverse engineering, medical imaging, visualization, computer vision, virtual environments, etc. [92, 89, 93, 91, 71, 70, 73, 76, 75, 72, 67, 66, 68, 69, 74, 90, 24, 25, 23, 26].

Besides the prior research contributions, to realize the full potential of physics-based modeling and deformable modeling in visual computing and visualization applications, We have been continuing our endeavors to investigate new theory and explore new, powerful models that can lay a solid foundation for the framework of physics-based modeling. In particular, our more recent research activities have been concentrated on the following topics:

- We proposed a new family of deformable models that are founded upon the concept of PDE-based, Lagrangian surface flow and multiresolutional adaptive subdivision surfaces and demonstrated their usefulness in surface modeling and reconstruction, shape reconstruction from 2D images, interactive sculpting, reverse engineering, data segmentation, large-data visualization and exploration, and bio-medical applications [24, 25, 23, 26, 28, 20, 29, 27, 31, 30, 32].

- We proposed and developed a novel haptic approach for the direct manipulation of physics-based surfaces. The method permits users to interactively sculpt virtual material with a standard haptic device (e.g., PHANToM from SensAble Technology) and feel the physically realistic presence of virtual objects with proper force feedback throughout the geometric design process [10, 9, 8]. It has been demonstrated that our haptics-based approach can significantly improve human-computer interaction and facilitate the more intuitive sculpting and understanding by users on 3D physical objects [21, 22, 51].

- We formulated and developed physics-based deformable Catmull-Clark subdivision solids, and implemented a modeling and sculpting system based on free-form B-spline solids and Catmull-Clark solids for arbitrary topology [79, 85, 80, 81, 83, 82]. Furthermore, we proposed a new interpolatory, volumetric subdivision scheme for unstructured hexahedral meshes [77]. Most recently, we also integrate implicit surfaces into our volumetric subdivision modeling framework [78].

- We integrated deformable modeling techniques with popular Partial Differential Equation (PDE) surfaces and solids and developed a prototype software system in which users can interactively manipulate points, normals, curvatures, and arbitrary regions of PDE surfaces and solids in an intuitive and direct means [11, 12, 13, 14, 19]. Later, we further integrated PDE-based deformable techniques and implicit surface representations with applications in scattered data fitting, sketch-based shape reconstruction from partial inputs, medial axis extraction and manipulation, etc. [15, 16, 18, 17]

- We formulated and developed a novel numerical solver for physics-based objects founded on the signal processing theory of Laplacian Transform [94]. Our numerical integration method systematically offers users a unified formulation and algorithm for the realistic simulation of various dynamic behaviors such as thermodynamics, collision detection/avoidance, rigid-body motion, and fluid dynamics.

- We integrated haptic sculpting with volumetric implicit functions and developed a haptics-based solid modeling environment founded upon volumetric implicit solids [53, 54, 55, 56, 58].

- We have pioneered a novel Scalar-field based Free-Form Deformation (SFFD) technique founded upon the general flow constraints and implicit functions defined by sketching and manipulating scalar fields [57, 60, 59].

- We developed a new solid modeling and visualization method using trivariate simplex splines [52, 61]. Our trivariate simplex splines are hierarchical in nature and they can be used to represent both solid geometry and multi-dimensional, heterogeneous material attribute simultaneously.

- We pioneered a novel solid subdivision scheme based on box splines [4]. In addition, we have devised a new interpolatory subdivision scheme for volumetric models defined over simplicial complexes [5]. Most recently, we proposed a general modeling framework for multi-dimensional adaptive subdivision objects [6], which include non-manifold geometry as their special cases.

- We have devised efficient and powerful algorithms for the automatic determination of all the unknown knot vectors associated with non-uniform rational subdivision schemes [106, 101].

- We developed several new surface reconstruction technique for noisy point clouds [107, 102]. Our novel methods are based on the concept of local implicit quadric regression. We can achieve piecewise C^1 continuous surface reconstruction from defective, noisy data sets.

- We have applied the principle of physics-based modeling and design to other, more general graphics applications such as texture and feature mapping. As a result, we have developed *ElasticPaint*: A physics-based, particle system for feature mapping with the least distortion subject to boundary constraints [3].

- We pioneered a novel paradigm for the dynamic sculpting, interactive editing, and deformation of point-sampled geometry and point set surfaces, by unifying the advantages of implicit surfaces, the strength of physics-based modeling techniques, and the simplicity of point sampled surfaces [41, 36, 38, 39, 37, 1, 42].

- We have developed a new surface content completion framework that can restore both shape and appearance from scanned, incomplete point set inputs [87, 88].
- We have extended triangular B-splines defined over a planar domain [49, 48, 98] to effectively construct manifold splines and spherical splines [34, 43, 47, 46, 35].
- We have applied triangular B-splines, spherical splines, and manifold splines to various applications including surface fairing, brain surface modeling, and medical image registration [47, 45, 99, 100].
- We have developed a hybrid physics-based subdivision scheme that can tightly couple physical/dynamic parameters and subdivision rules [96, 95].
- We have devised a novel solution to the problem of computing continuous maps with different homotopy types between two arbitrary triangulated meshes with the same topology, and our new surface mapping techniques are fundamental, topology-driven, and unique, while robustly aligning user-specified features [2].
- We have developed a meshless thin-shell simulation technique based on the concept of global conformal parameterization for point set surfaces [40].

Our research efforts have resulted in more than 100 journal and conference publications (including more than 30 journal papers and more than 70 conference papers) during the past ten years. During the past two years, in particular, I have submitted and published more than 30 papers in world-class journals and international conferences. Among the papers which were published during the last two years, one of our Solid Modeling 2004 papers received the Best Paper Award:

- "Multiresolution Heterogeneous Solid Modeling and Visualization Using Trivariate Simplex Splines," Jing Hua, Ying He, and Hong Qin, *Proceedings of the Ninth ACM Symposium on Solid Modeling and Applications (Solid Modeling 2004)*, June 9-11, 2004, Genova, Italy, pages 47 – 58, **(ACM Solid Modeling and Applications Symposium Best Paper Award)**.

During the past several months in late 2005 and early 2006, I have also submitted more than 10 journal and conference papers for review [44, 84, 7, 97, 86, 64, 63, 50, 33, 65, 62]. The details of my journal and conference publications have been documented in my curriculum vitae (please see the attached CV).

Now, I shall summarize some of previous and on-going research projects as well as their long-term objectives (sponsored by National Science Foundation, Honda Initiation Award, and Alfred P. Sloan Research Fellowship). Other research projects and the associated tasks have been documented in my curriculum vitae.

NSF/CAREER: Physics-Based Computer Aided Geometric Design: Theory and Applications

Computer-aided geometric design (CAGD) is of fundamental importance in computer-integrated engineering and manufacturing, computer graphics and visualization, robotics, and other disciplines. This CAREER project aims to develop **Physics-Based Computer Aided Geometric Design**, a new interdisciplinary paradigm which marries geometric modeling with computational physics. The objective is to dramatically enhance the CAGD process by creating advanced models with highly intuitive behaviors that are governed by physical principles. This initiative promises to yield highly interactive CAGD techniques. In particular, this research tackles, at both a theoretical and a practical level, the challenging problem of incorporating physical dynamics into parametric and implicit geometric primitives. We develop an extensive set of efficient algorithms that incorporate physics-based modeling principles into industry-standard design techniques.

This project is directly inspired by the PI's previous research on Dynamic Nonuniform Rational B-Splines (D-NURBS). D-NURBS are a physics-based generalization of industry-standard geometric NURBS in CAD. The initial results with D-NURBS have demonstrated the advantages of physics-based free-form modeling to conventional, purely geometric CAGD techniques for many design tasks. To realize the full potential of physics-based modeling in computer applications and industrial practice, however, we must build upon our pioneering efforts to arrive at a more thorough mastery of physics-based CAGD, both in terms of their theoretical and in terms of their practical aspects. Our research takes the following three-fold approach.

First, we continue our research efforts on D-NURBS with emphasis on the following topics: (1) optimization of the numerical algorithms involved in physics-based CAGD (including finite-element assembly, sparse matrix calculation, and the integration of motion equations), analysis of their complexity, and investigation of other fundamental numerical characteristics, such as stability, robustness, and accuracy; (2) incorporation of the knot variables of standard geometric NURBS into the generalized coordinates of D-NURBS, so that optimal knot vectors can be determined automatically in accordance with functional requirements and sculpting operations; (3) incorporation of "real" material properties within the D-NURBS physical parameter set; (4) qualitative and quantitative evaluation of the effects of physical parameter values on desired shapes; and (5) exploration of the theory and practice of the new D-NURBS finite element method in engineering applications. Second, we explore and devise novel physics-based modeling techniques and algorithms based on powerful new representations, including subdivision wavelets, manifold splines, and implicit functions. Third, we exploit the theoretical advances of the earlier stages of our research to develop an interactive physics-based CAGD software system that integrates a set of physics-based modeling tools. Our objective is to apply this software system to a wide range of CAGD applications. We hope to demonstrate that not only can physics-based CAGD serve as a unified basis for various traditional design techniques but that it can also be useful in computer graphics, visualization, vision, virtual reality, etc.

Throughout this research project, we aggressively integrate research and education through the following initiatives: (1) develop new graduate and undergraduate courses; (2) write a textbook on physics-based CAGD; (3) promote and participate in interdisciplinary research projects; (4) produce highly trained personnel by supervising graduate students, directing senior projects of undergraduate students, participating in outreach and mentoring programs, etc; and (5) promote the rapid dissemination of physics-based CAGD technology to national enterprise through collaboration with the CAGD industry. These career development activities not only advance the state of the art of CAGD, but that they also make significant contributions to geometric and solid modeling, graphics, scientific visualization, robotics, computational vision, and virtual environments.

NSF: A Physics-Based Geometric Modeling and Design System

The long-term objective of this project is to develop an integrated environment for interactive design founded on a new, physics-based geometric modeling and design methodology. Computer-aided engineering design is an innovative skill comprising the iteration of a set of complex processes, including conceptual design, analysis, evaluation, prototyping, and manufacturing. Optimal design can be accomplished through the repeated modification of numerous parameters, also called degrees of freedom (DOFs), that define geometric primitives. When the goal is to design complex real-world objects, conventional interactive design approaches can be laborious and inefficient, despite the use of advanced CAD systems with specialized graphical user interfaces. To improve the efficiency of interactive optimal design, we systematically develop a new design methodology founded on the theory of physics-based modeling. Furthermore, we develop a novel interactive design environment that integrates traditional design principles with physics-based design techniques. Our integrated environment can help to improve product quality, reduce product cost, and increase the effectiveness of design engineers.

This project is strongly motivated by the PI's prior research on Dynamic Nonuniform Rational B-Splines, or D-NURBS. To realize the full potential of physics-based modeling in industrial practice, we must build upon our pioneering efforts to arrive at a more thorough mastery of physics-based modeling techniques, both in terms of their theoretical and in terms of their practical aspects. Our research takes the following three-fold approach.

First, we continue our research efforts on D-NURBS with a focus on the following topics: (1) optimize the numerical algorithms involved in physics-based modeling and design (including D-NURBS finite-element assembly, sparse matrix calculation, and the integration of motion equations), analyze their complexity, and investigate other fundamental numerical characteristics, such as stability, robustness, and accuracy; (2) incorporate the knot variables of standard geometric NURBS into the generalized coordinates of D-NURBS (which currently comprise control points and weights) so that optimal knot vectors can be determined automatically in accordance with functional requirements and sculpting operations; (3) incorporate "real" material properties within the D-NURBS physical parameter set; and (4) evaluate, both qualitatively and quantitatively, the effects of physical parameter values on desired shapes.

Second, we systematically explore physics-based design techniques. Our objective is to devise a set of new force-based design toolkits and to investigate the effective integration of physics-based design with existing geometric design techniques and approaches.

Third, we integrate all the theoretical advances gained in prior stages of our research and develop an experimental physics-based design environment with real-time interactive capability. The new design system can not only provide designers most existing design techniques but also offer them a library of force-based sculpting tools for direct manipulation of free-form models. Throughout the duration of the project, we aggressively pursue industrial collaborations and disseminate D-NURBS technology and the associated software to the U.S. CAD/CAM industry. More importantly, this project will not only advance the state of the art of computer-integrated engineering but that it will also make significant contributions to geometric and solid modeling, graphics, scientific visualization, robotics, computational vision, and virtual environments.

ITR/HCI: An Interactive Graphical Modeling System based on Dynamic Subdivision Splines

The vision of our **Information Technology Research** is to develop software environments that can greatly facilitate human-computer interaction through the physics-based modeling of graphical entities. Our approach broadens the accessibility of graphical modeling by combining conventional geometric models with computational physics, thus offering novel interactive methodologies based on realistic model behavior.

In particular, the technical challenge of the proposed investigation focuses on the interactive manipulation and direct sculpting of Subdivision Splines (S-splines). Recent years have seen dramatic growth in the use of S-splines for graphical modeling and animation, especially for the representation of smooth, oftentimes complex shapes of arbitrary topology. Unfortunately, conventional interactive approaches to subdivision objects can be extremely laborious and inefficient. Modelers must carefully specify the initial mesh and/or painstakingly manipulate the control vertices at different levels of the subdivision hierarchy in order to satisfy the functional requirements and aesthetic criteria in the modeled object.

In this initiative, we strive to realize the full potential of combining physics-based interaction with powerful subdivision geometry, both in terms of its theoretical aspects and its practical aspects in visual computing applications. In particular, we concentrate our endeavors on dynamic interaction with subdivision geometry through the following three-fold approach:

1. We first focus on fundamental theory relevant to real-time dynamic sculpting with emphasis on the following topics: (1) the development and optimization of numerical and symbolic algorithms needed to support dynamic interaction, the analysis of their time and space complexity, as well as other standards, including stability, robustness, accuracy, and error bounds; (2) the development of novel subdivision rules that support local, adaptive subdivision; (3) the design of geometric and dynamic algorithms that permit the automatic topological modification of S-splines; (4) the incorporation of realistic material properties within the physical parameter set; and (5) the evaluation, both qualitatively and quantitatively, of the effects of physical parameter values on desired shapes.

2. We integrate all the theoretical and algorithmic advances achieved in the previous stage and develop an experimental dynamic S-splines environment with real-time, interactive capability. Our dynamic environment can offer users a library of modeling, design, and simulation tools for direct manipulation and intuitive sculpting of S-splines.

3. We aggressively pursue industrial collaboration, seek further corporate financial support, and disseminate the core technology of dynamic S-splines and the prototype software to U.S. information technology enterprises. Corporate collaboration can also (1) expedite the systematic evaluation of both system utilities and human factors involved in dynamic interaction, (2) verify the applicability of sculpting toolkits, and furthermore (3) validate the practicality of physics-based modeling environments.

The primary thrusts of this initiative are to help improve human-computer interaction methodologies, develop new interface modes, make physics-based interaction accessible to all users, and enhance the capabilities of graphical modelers. Meanwhile, we also aggressively pursue the educational goal of incorporating the theory and algorithms that we develop into the SUNYSB-CS curriculum and perpetuate the knowledge that we gain throughout various academic communities. It is our hope that our framework can not only advance the state of the art of human-computer interaction technology, but also geometric modeling, computer graphics, visualization, robotics, and virtual environments.

NSF: A Haptics-based Interface and Interactive Sculpting System for Virtual Environments

The technical vision of this cross-disciplinary initiative is to develop an interactive, **tangible** virtual environment that can significantly advance the current state-of-the-art in human-computer interaction through the novel integration of dynamic modeling and real-time haptic sculpting.

Computer-centered engineering design consists of a variety of complex and challenging processes, ranging from conceptual design, geometric modeling, evaluation, prototyping, manufacturing, assembly, to production. To ameliorate CAD/CAM processes, we have pioneered the novel, physics-based modeling technology. To realize the full potential of physics-based design in industrial practice as well as to revolutionize human-computer interaction technology, we center our endeavors on the R&D activities of real-time physical interaction coupled with realistic haptic sculpting capabilities. In particular, we conduct various research tasks through the following four-fold approach:

1. We focus on the following fundamental issues critical to the haptic sculpting: (1) optimize the numerical and symbolic algorithms involved in the haptic interaction, analyze their time and space complexity, and investigate other key characteristics, such as stability, robustness, and error bound; (2) develop the numerical and symbolic algorithms for the rapid and accurate synchronization of multiple (and heterogeneous) representations of the underlying geometric primitives and conduct the accuracy analysis. Maintaining multiple representations and minimizing the approximation error associated with data exchange among different representations for the same sculpted object is vital to sustain the time-critical haptic interaction in virtual environments; (3) incorporate "real" material properties within the physical parameter set; and (4) evaluate, both qualitatively and quantitatively, the effect of physical parameter values on desired shapes.

2. We systematically investigate haptic interaction techniques towards the next-generation design technology. Our objective is to (1) devise a set of novel haptic sculpting toolkits, (2) pursue the accurate evaluation of both toolkit utilities and human factors uniquely associated with haptic interaction through the extensive collaboration in both academia and industry, and (3) investigate and articulate the effective integration of haptic principles with mature geometric design techniques.

3. We unify all the prior theoretical advances and develop an experimental virtual environment with real-time haptic sculpting capabilities. This novel system can not only allow designers to directly sculpt free-form models with haptic devices for conceptual design, but also permit them to conduct various downstream design tasks such as finite element analysis and virtual prototyping. We aim to disseminate the novel haptic technology and its software to the U.S. design industry and computer enterprises. Extensive corporate and academic collaboration

can also (1) verify and facilitate the applicability of haptic toolkits, and further (2) confirm and validate the practicality of haptics-based virtual environments.

4. To further broaden the accessibility of our new haptic technology in engineering, sciences, and medicine, we make extra efforts (through extensive collaborations) towards generalizing our software system to other haptics-relevant applications such as surgical simulation and training, and haptic visualization of large scientific data sets.

Novel and natural human-computer interaction techniques underpin the success of future design technology. Therefore, it is our hope that this project will not only advance the state of the knowledge of computer-integrated engineering in improving product quality, reducing product cost, and increasing the effectiveness of design engineers, but that it will also make significant contributions to human-computer interface methodology and interactive techniques.

NSF/VISUALIZATION: Multiresolution, Adaptive, Subdivision Surfaces for Interactive Visualization and Exploration

One fundamental research challenge of advanced computational science is to aid scientists, researchers, engineers, and general users to gain a better understanding of large-scale datasets acquired from either computer simulations or real-world experiments. Therefore, it demands better modeling, analysis, and visualization tools that can reveal the insight from raw datasets and facilitate the interpretation of high-level knowledge. Towards this goal, the technical vision in this cross-disciplinary project is to develop novel algorithmic and computational techniques founded upon the principle of the deformable modeling paradigm for manipulating, simulating, visualizing, and processing any large-scale, complex dataset, hence leading to a better understanding of the higher-level, more meaningful information hidden within raw data subject to uncertainty and noise.

Deformable models are geometric object models whose dynamic behaviors are governed by variational principles (VPs) and/or partial differential equations (PDEs). They have proven extremely powerful in an increasing number of applications spanning the fields of computer graphics, geometric design, computer vision, scientific visualization, and finite element simulation. This research initiative aims to develop new theoretic, algorithmic, computational, and software techniques within the mathematically rich and broadly applicable deformable models paradigm, with an ambitious goal to further revolutionize deformable models and promote them as a valuable visualization and exploration tool.

The **Intellectual Merit** of the proposed research is the technical approach of developing a suite of novel deformable models and presenting an integrated methodology for modeling and visualizing both complicated geometric information and arbitrarily, unknown topological structure in large-scale, complex datasets. The essence of our novel deformable models is multiresolution, level-of-detail (LOD), and subdivision geometry whose topology is also dynamically adaptive subject to VPs and PDEs.

The **Broader Impacts** of the proposed research are as follows: Through an array of research activities, this investigation is expected to dramatically advance the state of the art in the aforementioned fields, all of which have strategic value in the US information technology industry. Complementary subgoals will be to demonstrate that the novel deformable models are not only a powerful modeling, rendering, and simulation tool for visual information processing, but that they can potentially serve as a general computational technology to aid in new scientific exploration. In particular, our novel models can be deployed in large-scale datasets to automatically extract geometric boundaries and discover their unknown topology for any regions of interest within the dataset. These new models can alleviate the burden of laborious human operations for the processing of large-scale datasets, enhance the efficiency of domain scientists as well as ordinary users, facilitate modeling and rendering tasks, and streamline the entire pipeline of visual information processing.

We shall incorporate the newly-developed theory and algorithms into the graduate curricula in computer science, applied mathematics, and statistics at SUNY-SB's Departments of Computer Science and Applied Mathematics and Statistics. These curricula will expose graduate students to a novel perspective on visual computing based on deformable models, which will significantly improve their problem-solving skills in an interdisciplinary context. We also seek collaborations with industry to provide the longer-term financial support for technology transfer of the prototype software.

NSF/ITR: Intelligent Deformable Models

Deformable models and level set methods are related techniques that have proven to be phenomenally successful computational tools across a variety of disciplines, ranging from computer vision and image processing, computer graphics and image synthesis, computer-aided design and geometric modeling, as well as in applied mathematics and physics. The two techniques, each a major investigative avenue in itself, are complementary in several fundamental ways. The goal of this project is, for the first time, to harness the complementary strengths of these two physics-based methods. We will do so by unifying them under a biology-based control paradigm derived from the emerging field of artificial life. Our unification will lead to a novel breed of intelligent, *deformable organisms* capable of performing a wide range of challenging data analysis tasks, such as image segmentation and data reconstruction, in a highly automated fashion.

The **Intellectual Merit** of the proposed research is the goal of incorporating within an ultimately symbolic control hierarchy, two fundamentally numeric methods, the first related to the continuum mechanics of solids, the second related to liquids. Hence, deformable models maintain their topological structure as they evolve, while level set methods are topologically adaptive. Enabling these methods seamlessly to join forces within a rigorous mathematical and tractable computational foundation is an intellectually challenging problem. The research team, whose expertise spans the computational and mathematical sciences and includes the inventors of deformable models and level set methods, is uniquely qualified to meet this challenge. The anticipated outcome is a new, highly automated methodology for analyzing large-scale datasets that are subject to uncertainty and noise.

The **Broader Impacts** of the proposed research are expected to be as follows: Through an array of research activities, this investigation will dramatically advance the state of the art in the aforementioned fields, all of which have strategic value in the US information technology industry. Complementary subgoals will be to demonstrate that the new modeling paradigm is not only a powerful analysis tool for visual information processing, but that it can potentially serve as a general computational technology to aid in new scientific discovery. In particular, our novel models can be deployed in massive datasets to automatically extract geometric boundaries and discover their unknown topology of structures of interest within the data. For example, with the vast quantities of medical images routinely collected for diagnostic and research purposes, this project will serve the critical need for the development of tools to aid in their analysis. These new models can alleviate the burden of laborious human operation for the processing of large-scale datasets, enhance the efficiency of domain scientists as well as ordinary users, facilitate modeling and rendering tasks, and streamline the entire visual information processing pipeline.

The research team aims to incorporate the newly-developed theory and algorithms into the graduate curricula in computer science and mathematics at NYU's Courant Institute, UCLA's Mathematics Department, and the computer science departments at SUNY-SB and Stanford (note that, this is a joint project which involves SUNYSB, NYU, UCLA, and Stanford). These curricula will expose graduate students to a novel unified perspective on visual computing based on deformable models, level set methods, and perceptual/behavioral/cognitive control, which will significantly improve their problem-solving skills in an interdisciplinary context. The PIs are seeking collaborations with industry to provide the longer-term financial support for technology transfer of the prototype software.

Honda Initiation Award: Physics-based Technology and System for the Next-generation, Integrated CAE/CAD/CIM

The technical vision of this cross-disciplinary research is to develop novel engineering theory, modeling and design techniques, and an interactive design environment founded upon physics-based technology. The primary thrusts of this grant are to help improve product quality, shorten product development cycles, reduce product cost, and enhance the capabilities of design engineers, both for Honda's R&D undertakings in particular and for the CAD/CAM industry in general.

Computer-centered product development process comprises the iteration of many steps, including conceptual and geometric design, shape modeling, finite element analysis (FEA), prototyping, etc. In this process, defining and refining product geometry is often the most critical undertaking because geometry significantly affects all downstream activities in terms of time, quality, feasibility, manufacturing costs, etc. The geometry of a product can generally be described in different forms, or mathematical representations. During the life cycle of a product development process, different forms are used for different design and engineering purposes. For instance, NURBS-based representations dominate the earlier design stage; polynomial-based finite element form are indispensable during product evaluation and safety test; and polyhedral meshes derived from NURBS are invaluable for visualization and digital prototyping. For designing industrial products like automobiles and their constituent parts, the integration of different geometric models is an extremely complex and difficult task.

To ameliorate CAE/CAD/CIM processes, we pioneer a novel theory and articulate a new engineering technology, founded upon the physics-based design methodology, which integrates product geometry with physical and material properties, thus providing a unique opportunity to automatically synchronize and integrate different models through direct mathematical and physical "links", that are precise and instantaneous. For example, engineers can interactive refine NURBS geometry through physical forces that can afford the simultaneous modification of accompanying finite element polynomials and/or polygonal meshes (and vice versa), because diverse geometric forms share the same physical properties. Based on the same reason, this integrated philosophy also permits engineers to study sheet metal behavior subject to external forces and focus on the shape design in a parallel fashion. This initiative proposes to develop a proof-of-concept software system that integrates multiple and heterogeneous formulations (spanning across the various CAD/CAM processes) of the same physical object automatically in a production environment. These geometric representations will be tightly and precisely synchronized by means of physics-based direct manipulation. The system will be open-architectured, allowing continuously evolving towards better and more efficient functionalities. The deliverables will also include a suite of easy-to-use CAD tools uniquely tailored for a host of Honda's CAE/CAD/CIM applications. The ultimate goal is to assist Honda in its quest for shorter product development time and maintain CAE/CAD/CIM technological advantage over its competitors.

2001 Alfred P. Sloan Research Fellowship: Geometric and Visual Computing

My prior and current research fields span from geometric modeling, CAGD, computer graphics, CAD/CAM, and other visual computing fields. Under the previous NSF grants (including CAREER award) and other industrial supports, I have proposed and developed a new design methodology—the physics-based geometric modeling and design paradigm—which can integrate geometric objects with physical and material properties, thus allowing intuitive interaction with geometric objects by means of forces, energies, constraints, etc. In particular, I have developed a set of meaningful sculpting tools that can expedite the direct manipulation of Dynamic NURBS (D-NURBS), FEM-based subdivision splines, and multiresolution wavelet splines. My on-going research activities indicate a promising future for these dynamic models in various engineering applications such as computer-aided design, graphics, finite element analysis, reverse engineering, etc.

To realize the full potential of physics-based modeling in geometric and visual computing applications, I will continue my endeavors to investigate new theory, explore new, powerful models, and develop innovative systems that will lay a solid foundation for the framework of the future generation of physics-based CAD/CAM. In particular, I will conduct various research activities towards an interactive, computer-integrated virtual environment for the unified engineering design, analysis, and manufacturing. The technical vision of my future research is to advance the state-of-the-art knowledge of the entire CAD/CAM processes and forge ahead to achieve the ultimate objective of computer-integrated virtual engineering. CAD/CAM is an iterative operation which comprises conceptual design, detailed part drafting, finite element analysis, evaluation, part assembly, prototyping, and manufacturing. The advent of Virtual Reality (VR) and internet technologies make it both possible and necessary to revolutionize traditional design and manufacturing techniques and systems. The new computer-integrated virtual engineering promises the significant cost-reduction of performing CAD/CAM processes. The concrete research plan includes: (1) research and develop physics-based interaction tools that permit designers to interactively create and modify product geometry with haptic feedback, and further examine design requirements and criteria in real-time; (2) investigate graphical models and visualization tools that support the effective graphical simulation of finite element analysis through the extensive use of D-NURBS finite elements and FEM-based subdivision splines; (3) explore and develop graphical tools that can simulate manufacturing process without the need of physically manufacturing the mechanical part; (4) develop other simulation tools to facilitate the process of decision making, the generation of alternative design configurations, the assessment of product assembly-ability, etc. Through the

VR-based CAD/CAM simulation, it is also our hope that this system can provide a test-bed to verify new algorithms and ideas for design and manufacturing purposes. Throughout this research, I shall focus on large scale, complex, real-world CAD models and/or real objects. To make the maximum use of the state-of-the-art graphics and VR facilities in the Center of Visual Computing (CVC) at Stony Brook, I shall also lead efforts to investigate the design of parallel algorithms and develop distributed design tools that can transform our physics-based CAD/CAM system into a distributed environment.

NSF/SGER: Exploring Digital Sculpture with Two-hand Haptics

Despite the most recent advancement of computing and interaction technologies, it still remains a great technical challenge to faithfully and efficiently represent real-world objects in a digital computer and to develop effective human-computer interfaces for managing and communicating with such CAD models. In particular, no one has yet developed a robust graphical model and accompanying human-computer interface that can simultaneously (i) represent volumetric shapes of arbitrary topology and anisotropic material distributions; (ii) efficiently simulate complex physical and dynamic behaviors in real time; and (iii) facilitate natural, convenient interaction between human users and such 3D digital representations.

The goal of this **small-scale, exploratory, and high-risk** initiative is to tackle the aforementioned challenges in a two-fold process: to bridge the large gap between real-world physical objects and CAD-based digital models, and to improve the communication and interaction between human beings and computerized virtual environments (VEs). In particular, the technical vision of the proposed **SGER** project is to develop **Digital Sculpture**, a novel two-hand haptic interface for HCI. Digital Sculpture will include a suite of new, graphical models for representing volumetric shapes as well as two-hand, haptics-based interactive techniques for managing and manipulating our new representations. Our efforts will include the development of new theoretic, algorithmic, computational, and software techniques that will facilitate the interaction of Digital Sculpture in VEs via a two-hand haptic interface. At present, two-hand haptic systems have been severely under-explored. An important outcome of this project will be the comprehensive investigation of a two-hand haptic system.

Intellectual Merits: The intellectual merits of the proposed research are two-fold. First, this initiative primarily concentrates on haptic modeling and usability study for two-hand haptic interfaces. Our Digital Sculpture employs a new solid subdivision scheme that unifies modeling and animation for both geometry and material properties within one single physical framework. Digital Sculpture will be deployed as a new means for the two-way HCI, which affords the user to examine, modify, and animate digital models with a novel two-hand haptic interface. Second, with respect to the evaluation study, we plan to validate the effectiveness of Digital Sculpture via comprehensive usability studies. In particular, we plan to extensively compare our technique and paradigm with existing ones in order to assess the benefit of the anticipated improvements. We are planning a comparison of one-hand vs. two-hand haptic sculpting to assess the gains provided by a haptic input from a second glove, even under conditions when the second glove remains stationary.

Broader Impacts: Through a suite of research activities, the broader impact of this initiative will be both fundamental and profound to the enhancement of human-computer interface techniques in a much wider spectrum of real applications as well as the broadening of computer accessibility by human beings. One key outcome of this **small-scale, exploratory, and high-risk**

research is the novel HCI paradigm of a two-hand haptic system. Although the main driving application for this initiative is computer-aided engineering, such a two-hand haptic interface will be invaluable in all applications in which 3D structures must be manipulated, such as surgical simulation and virtual sculpting. The comprehensive study of novel, two-hand haptic interaction techniques can further deepen our understanding into haptic-based HCI.

Besides the aforementioned (previous or on-going) projects, the complete list of my funded projected is documented in my CV. Because of my prior research accomplishments, I received the **Research Excellence Award** at Department of Computer Science in 2004:

- **Research Excellence Award, Department of Computer Science, State University of New York at Stony Brook, August, 2004.**

Industrial Collaborations

During the last ten years, I have been actively seeking industrial collaborators and corporate financial support via frequent visits in industry. Our research on physics-based modeling and design has been attracting tremendous interest primarily in CAD/CAM and software industry (as well as academic communities). As a result, I has had opportunities to present our research results at various research seminars in the following companies and national labs:

- "DYNASOAR: DYNAmic Solid Objects of ARbitrary topology," at *Microsoft Research Asia*, Beijing, P.R. China, May 30, 2002.
- "Intelligent Balloon: A Subdivision-Based Deformable Model for Surface Reconstruction of Arbitrary, Unknown Topology," at *Ford Motor Company Research Laboratory*, Dearborn, Michigan, June 7, 2001.
- "Physics-Based Modeling For Visual Computing Applications," at *SGI Alias | Wavefront, Toronto*, June 13, 2000.
- "Physics-Based Modeling for Visual Computing Applications," at *Center for Data Intensive Computing, Brookhaven National Laboratory*, April 14, 2000.
- "Physics-Based Modeling for Engineering Design," at *Ford Motor Company Research Laboratory*, Dearborn, Michigan, June 9, 1999.
- "Physics-Based Modeling and Shape Design Framework for CAD/CAM, Graphics, and Visualization," at *National Institute of Standards and Technology (NIST)*, Gaithersburg, Maryland, December 14, 1998.
- "Dynamic Catmull-Clark Subdivision Surfaces," at *Naval Research Laboratory,* Washington, D.C., June 1, 1998.
- "Physics-Based Modeling Framework for Graphics, CAD, and Visualization," at *IBM T.J. Watson Research Center*, Hawthorne, New York, April 27, 1998.
- "Physics-Based Catmull-Clark Subdivision Surfaces for CAD/CAM," at *Structural Dynamics Research Corporation*, Milford, Ohio, April 24, 1998.
- "Towards an Interactive Physics-Based Design Environment for Automobile CAD/CAM," at *Ford Motor Company Research Laboratory,* Dearborn, Michigan, January 30, 1997.
- "Physics-Based Geometric Modeling and Design," at *Structural Dynamics Research Corporation,* Milford, Ohio, November 8, 1996.
- "Dynamic Non-Uniform Rational B-Splines," at *XOX Corporation*, St. Paul, Minnesota, October 20, 1995.
- "Dynamic Non-Uniform Rational B-Splines," at *SGI Alias | Wavefront*, Toronto, Ontario, September 6, 1995.

One key objective of my research and development activities is to promote the rapid dissemination of our research and development results (on physics-based modeling and design in particular), as well as our prototype software environments within the U.S. information technology industry. These lectures have been providing the impetus for rapid dissemination of novel concepts of physics-based methodology and techniques. Meanwhile, industrial interest has also been increasing. Scientists, design engineers, and executives from several corporations such as SGI Alias||Wavefront (Toronto), Structural Dynamics Research Corporation (Milford, OH), Visionary Design Systems (Atlanta, GA), Ford (Dearborn, MI), GE (Schenectady, NY), IBM (Hawthorne, NY), XoX Corporation (St. Paul, MN), and NIST (Gaithersburg, MD) had indicated their interest to pursue collaborative research and development with my group. In particular, I have been communicating with Ford and SDRC, exploring the possibility to install our prototype software at their $R\&D$ sites. This promises to give potential clients "a glimpse into the next generation of geometric modeling and design" in order to stir more interest in Ford and SDRC's commercial offerings.

Through extensive industrial collaborations, I hope to see an increase in the technical and financial investment on developing commercial software systems based on our research results. However, the industrial impact has yet to come. I anticipate that the industrial partners will participate to the extent of supporting our research in the near future by supplying equipments and software. For example, SDRC has made their I-DEAS package available in our departmental facilities through an in-kind contribution. Furthermore, the corporate support will speed up technology transfer—in particular, the integration of our research results into commercial modeling and design systems—by influencing and guiding our $R\&D$ efforts. All of these activities have provided me the opportunity to (1) disseminate knowledge in academic and industrial communities, (2) pursue domestic and international collaborations, and (3) contribute to the development of highly qualified personnel for the benefit of U.S. education and the economy. Because of my active pursuit of industrial collaborations, during the last eight years, I have been able to secure the following grants from industry and national labs:

- Principal Investigator, "Parallel Software Development for BNL Aerosol Chemical Transport and Transformation Model," Brookhaven National Laboratory, \$27,062, November 2001 to October 2002.

- Principal Investigator, "Parallel Computation Techniques and System Development for Chemical Transport Modeling and Simulation," Brookhaven National Laboratory, \$15,432, May 2001 to November 2001.

- Principal Investigator, "Novel Engineering Design Techniques for the Next-Generation, Integrated CAE/CAD/CIM in Automobile Industry," Sensor CAT of New York State, \$8,000, January 2001 to December 2001.

- Principal Investigator, "Physics-Based Technology and System for the Next-Generation, Integrated CAE/CAD/CIM," Honda Initiation Grant Award, \$30,000, January 2001 to December 2001 (also see http://research.honda.com for the details).

- Software Gift Donation from Structural Dynamics Research Corporation (SDRC), SDRC I-DEAS software system, \$158,000 per user, 28 simultaneous users, total \$4,424,000 to SUNY at Stony Brook.

- Principal Investigator, "Graphical Modeling, Statistical Analysis, and Visualization of Large Warehouse Datasets," SUNY SPIR program and Robocom Systems International, \$26,167, January 2000 to July 2000.

- Principal Investigator, "A Software Tool for Graphical Understanding and Decision Making in Large Warehouse Datasets," SUNY SPIR program and Robocom Systems International, \$38,496, June 2000 to December 2000.

- Principal Investigator, "An Interactive, Physics-Based, Computer-Integrated Design Environment for Automotive CAD/CAM/CAE," Ford Motor Company, \$37,500, May 1997 to May 1999.

In addition to the prior research endeavors and accomplishments, I also made significant efforts toward excellence in both research and education, including: (1) technical presentation of our research advances in other universities and companies via various research seminars; (2) development of several new graduate and undergraduate courses that have been incorporated into our curriculum and have been offered to all students within SUNYSB; (3) establishment of a new physics-based modeling and simulation research group within our Center for Visual Computing, etc. All of these activities will be documented in details in the following sections.

Course Teaching

This section summarizes my contributions to the mission of both undergraduate and graduate teaching at SUNYSB (as well as at the University of Florida (UFL)) from the very start of my academic appointment.

During the last ten years, I have taught a wide variety of courses in different fields of visual computing, including **Computer Graphics**, **Scientific Visualization**, **Geometric Modeling**, and **Physics-based Modeling and Simulation** at undergraduate level, introductory graduate level, and advanced graduate level. Meanwhile, I have been offering a research seminar course in geometric modeling and physical simulation ever since 1998 for the last eight years (including spring, summer, and fall semesters). In addition, my teaching interests also include: **Computer Aided Design**, **Virtual Reality**, **Human-Computer Interaction**, **Computer Animation and Simulation**, and **Numerical Techniques and Analysis**. The complete teaching record can be found in my curriculum vitae.

Prior to my appointment at SUNYSB, I was a tenure-track assistant professor at Department of Computer & Information Science & Engineering (CISE) in UFL. During my tenure at UFL (in 1996 and 1997), I was responsible for lectures in three courses in the CISE curriculum at UFL:

- **CAP4700: Introduction to Computer Graphics**, which is a undergraduate graphics course (twice in 1996 and 1997);
- **CAP5705: Computer Graphics**, which is an introductory graduate graphics course (twice in 1996 and 1997); and
- **CIS6930: Selected Topics on 3-D Interactive Graphics**, which is an advanced graduate graphics course (once in 1996).

I had improved these existing graphics courses by incorporating novel algorithms and approaches of physics-based modeling, computer-aided design, computer animation, visualization, and virtual reality into my lectures. My teaching evaluation in all of the above courses at UFL were excellent, based on student survey.

Since the fall of 1997 after I joined SUNYSB-CS, I taught the following courses:

- **CSE328: Fundamentals of Computer Graphics** (total seven times in Years 1999-2005),
- **CSE/ISE332: Introduction to Visualization** (once in 1998),
- **CSE530: Geometric Foundations for Graphics and Visualization** (total eight times in Years 1999-2006),
- **CSE564: Scientific Visualization** (once in 2004),
- **CSE621: Physics-based Modeling for Visual Computing** (total seven times in Years 1998, 2001-2006),
- **CSE655: Seminar in Modeling and Simulation** (every semester including summer semesters ever since 1998), and
- **EAS101: Introduction to Engineering and Applied Sciences** (once in 1999).

In all the courses I taught, I have developed comprehensive course notes and made them available to all students who attend the class. Especially since 1998, I have been making all the course materials available at our websites, and students can easily access all the lecture notes through either my website or the designated course website. Each year, I extend my course notes with up-to-date contents from either newly-published textbooks or novel research results. Other relevant course information presented on the web includes the syllabus, handouts, homework assignments, programming projects, detailed instructions for programming environments, sample examples, useful links to the relevant external resources, etc. (please see my homepage at http://www.cs.sunysb.edu/∼qin for the detailed course information). The course website is updated frequently whenever new and important information is incorporated. With the active involvement of my teaching assistants, I am also able to effectively help students by presenting the detailed compilation instructions and FAQs on programming environments through the WWW.

Curriculum Innovation and Development

Besides my aforementioned contributions in course teaching, I have also been aggressively pursuing the educational goal of incorporating the newly-developed theory and algorithms from recent research advances (especially those resulted from my own funded projects) into the CS curriculum. In particular, since 1997, I have been very active towards the improvement of our SUNYSB-CS curriculum, especially our graduate courses. My concrete goal was to develop new courses which did not yet exist in our CS curriculum at SUNYSB. First, I conducted a lot of research by seriously comparing our curriculum with that of other major CS departments throughout the nation and also by carefully examining the course offerings in AMS department. Then, I have worked very diligently to incorporate the novel domain knowledge in my areas of expertise into our graduate education, aiming to achieve the goal of the effective integration of both research and education towards the high-quality educational mission of our university. In particular, during the last eight years, I have developed the following new graduate courses:

- **CSE530: Geometric Foundations for Graphics and Visualization**,
- **CSE621: Physics-Based Modeling for Visual Computing**,
- **CSE655: Seminar in Modeling and Simulation**, and
- **CSE685: Special Topics in Modeling and Simulation**.

At present, these courses (along with their synopses) have been officially incorporated into the newly-published graduate bulletin of SUNYSB. I shall enclose their synopses below:

- **CSE530: Geometric Foundations for Graphics and Visualization.** This course will focus on mathematical tools, geometric modeling techniques, and fundamental algorithms, that are relevant to graphics, visualization, and other visual computing areas. The goal is to provide graduate students a comprehensive knowledge on geometric concepts and demonstrate the significance of these mathematical tools and geometric algorithms in graphics and relevant areas. Course topics include geometric algorithms for both polygonal and curved objects, theory of parametric and implicit representations, modeling methods of curves, surfaces, and solids, in-depth spline theory, rudiments of wavelet theory and multi-resolution shape representations, differential geometry fundamentals, and other sophisticated topics and latest advances in the field.

- **CSE621: Physics-Based Modeling for Visual Computing.** The central theme of this advanced graduate course is on physics-based modeling and dynamic simulation, as well as their widespread applications in the entire spectrum of visual computing discipline. Throughout this course, we take a unique, unified, physical approach to various visual computing fields such as graphics (image synthesis), visualization, computer-aided geometric design, biomedical image processing, vision (image analysis), human-computer interaction, and virtual environment. Our objective is to demonstrate that physics-based modeling and computing is a fundamental and enabling computational framework that can facilitate visual information processing in general. Towards this goal, the course will explore research topics centered on physics-based modeling and simulation methodology and associated computational methods for tackling theoretical and practical problems in widespread areas of visual computing. The specific emphasis will be on: the rich theory of mathematical physics, geometric and solid modeling based on PDEs and energy optimization, deformation-centered geometric design techniques, wavelets and multi-resolution analysis, deformable models for shape estimation and reverse engineering, variational analysis, optimization methods, level-set methods, numerical techniques with finite-difference and finite-element algorithms, differential equations for initial-value and boundary-value problems, force-driven haptic interaction, constraint satisfaction methods, dynamic sculpting system, animation of flexible objects, simulation of physical worlds, and a large variety of applications for visual computing.

- **CSE655: Seminar in Modeling and Simulation.** This seminar covers the latest advances and various research topics on (but not limited to) geometric, graphical, and visual modeling, general data and material modeling, new spline/subdivision schemes and their effective computation, shape representation and manipulation, modeling and reconstruction for geometric, scientific, and image data, dynamic simulation, mathematical tools for data modeling, deformation and editing, variational analysis, partial differential equations, finite element methods, computational techniques for simulation and analysis, haptic interaction, graphics rendering processes, and an wide array of visual computing applications such as CAD/CAM, CAGD, reverse engineering, graphics, visualization, vision, animation, digital geometric processing, medical imaging analysis, and human-computer interface. A large variety of papers from relevant fields will be presented and discussed in the seminar.

- **CSE685: Special Topics in Modeling and Simulation.** This is an advanced modeling and simulation course on selected research topics. This application-oriented course tries to address issues of modeling and simulation from graphics, animation, CAD/CAM, medicine, artificial life, and virtual environments. Primary areas covered this course include visual modeling, mathematical methods for geometry, shape design technology, computational physics for simulation, and scientific computing techniques. New topics will be added into the course each year in order to reflect the latest state-of-the-art development.

These new graduate courses have been officially listed in the SUNYSB computer science and engineering curriculum, and three of them have been offered to our graduate students annually. In the interest of space, I shall not include more details about these courses here. Please refer to Hong Qin's homepage (http://www.cs.sunysb.edu/∼qin) for the more detailed description of these courses. Since 1999, I have been offering CSE530 and CSE621 every year, and I have been offering CSE665 every semester including all the summer semesters to all of our M.S. and Ph.D students. I am teaching both CSE530 and CSE621 in the spring semester of 2006.

These new project-oriented courses which I have developed are of value to the great success of our program in computer science and engineering, because none of these course topics were covered in CS and AMS departments before. Throughout these courses, I particularly emphasize the novel knowledge, and theoretical and practical advances from multiple disciplines. My goal is to bring together diverse knowledge from graphics, geometric modeling, computer-aided design, visualization, finite element analysis, and numerical methods onto a single platform. Students taking these courses are exposed to knowledge that transcends the traditional boundaries of aforementioned areas. They are enabled to integrate the theoretical knowledge with problem-solving and engineering skills to tackle interdisciplinary research problems.

My expertise has allowed me to develop these new courses successfully and offer them to our graduate students on the regular basis (every year since 1999). In addition, I hope that it will continue to enhance our existing strength in the areas of visual computing, making our program on visual computing much more attractive and much better in terms of both research and education. Meanwhile, I also have a tangible plan to contribute to the curriculum innovation in our undergraduate program. In particular, I am planning in the near future to develop the following new 300-level course for our ever-increasing undergraduates:

- **Introduction to Scientific, Symbolic, and Graphical Computation**; and
- **Introduction to Human-Computer Interaction**.

which will complement our current offerings to our CSE/ISE senior undergraduate students.

During the last ten years (including my prior academic appointment at UFL), my teaching record has been excellent, based on both SUNYSB's and UFL's criteria. For example, based on the current SUNYSB scoring system (in which 1 denotes the best score), my graduate teaching evaluations have always been somewhere between 1.1 and 1.5 during the last eight years (please verify these numbers in the archived student evaluation sheets), this statistics is well above the university average, which is around 2.0.

Besides my offerings of graduate courses, undergraduates, and seminars in CS department, I also contributed in 1999 to the general educational mission of SUNYSB by teaching EAS101, an introductory orientation-type course for first-year engineering students.

Interdisciplinary Activities

Physics-based modeling techniques which I developed offer a useful, unique approach to tackling diverse research problems in the areas of engineering, science, and medicine. To maximize the impact of my research, I have been actively promoting the rapid dissemination of our research results through interdisciplinary collaboration and exploring the opportunities of applying physics-based modeling techniques to other relevant on-going research projects. For example, during 1996 and 1997 at UFL, I was collaborating with senior professors in the departments of mechanical engineering and nuclear engineering in the areas of robotics and virtual reality. Specific projects of interest include: (1) algorithm design and software development for the treatment of nuclear waste using unmanned robots; (2) a virtual environment for training engineers to conduct critical operations in nuclear plants; and (3) a dynamic design system in a virtual environment with force-back devices. During my tenure at UFL, I co-supervised one PhD student from mechanical engineering. In 1996 and 1997, I also collaborated with my colleagues at different departments across the UFL campus to compete for several national funding initiatives such as MURI. After I moved to SUNYSB, I have been communicating with several professors (e.g., Professors Peter Kahn and Doug Swesty) at Department of Physics and Astronomy to explore the opportunities of establishing certain formal mechanism towards possible joint, cross-disciplinary programs for both undergraduate and graduate students (e.g., the computer science minor specifically tailored for students of physics major or a special five-year program of computational physics). Through the development of relevant new courses in the areas of physical simulation and/or scientific computation, my unique expertise on physics-based modeling and simulation can help to bridge the gap among main-stream computer sciences, visual and scientific computing, and computational physics. This challenging task will require tremendous extra efforts in order to achieve the goal of facilitating interdisciplinary education and research. In addition, my other major cross-disciplinary efforts at SUNYSB since 1997 include:

- Being actively involved in a large variety of activities in the area of visual computing within CS department (chaired by Professor Arie Kaufman) through numerous collaborations on grant proposals, regular research meetings, paper publications, student supervision, and seminar series;

- Contributing to several large-scale equipment proposals every year towards the improvement of CS departmental infra-structure;

- Participating in many multi-departmental efforts to compete for new research initiatives (from national funding agencies such as NSF) through extensive collaborations with my colleagues in departments of Applied Mathematics and Statistics, Chemistry, Psychology, Mechanical Engineering, Marine Sciences, etc. (e.g., the 1999 NSF initiative on visualization of large dataset, the 2005 NSF Major Research Instrumentation initiative, etc.);

- Initiating and continuing the interaction with Professor Dale Drueckehammer of Chemistry Department and his students on a possible research project of applying the new geometric matching techniques to tackle the challenging drug-design problems;

- Collaborating with Professor Kenny Ye on two SPIR projects and continuing to pursue other opportunities with local companies through SUNY/SPIR initiatives;

- Extensively collaborating with the research scientists at Brookhaven National Laboratory on the two funded projects (please see my CV for the details), and continuing to pursue new possible funding opportunities at BNL and within DOE;
- Teaming up with faculty members from other universities in two multi-institutional proposals to compete for NSF Science and Technology Center (STC) during 1998–2000 in the areas of human-computer interaction and geometric computing, respectively. Besides SUNYSB, other participating universities include Georgia Institute of Technology, New York University, University of Texas at Austin, and University of North Carolina at Chapel Hill;
- Working with Professor Jeff Ge at ME department on the integration of Dynamic NURBS and kinematics-driven surfaces for the unified CAD/CAM processes;
- Teaming up with my colleagues in the University of Missouri at Columbia (Professor Ye Duan) and the University of California at Irvine (Professor Hongkai Zhao) to submit collaborative proposals to compete for NSF initiative on Interface between Computer Science and Mathematics in 2004 and 2005;
- Teaming up with my colleagues in Radiology Department of School of Medicine to apply for internal funding such as TRO (Targeted Research Opportunities) from the School of Medicine. In 2005, we applied for Carol M. Baldwin Breast Cancer Research Grants;
- Collaborating with my colleagues from Applied Mathematics and Statistics to apply for NSF IGERT grant in 2004;
- Working with my colleagues at Computer Science Department to jointly compete for various initiatives and to apply for numerous grants including NSF MRI grants, NSF infrastructure grants, and DHS (Department of Homeland Security) Regional Centers for Visual Analytics, etc.
- In every year during the last eight years, I have been collaborating with my colleagues (on multiple occasions each year) to jointly write proposals to compete for various initiatives such as MRI, CISE-RR, Research Infrastructure Grants, Equipment Grants, CRI initiative, ITR, etc.

Graduate Advising and Human Resource Development

Besides the excellence in research, education, and service, I have also been contributing to the development of human resources through the academic supervision of graduate and undergraduate students. At UFL, my first Ph.D student (at UFL) has successfully defended his Ph.D dissertation and received his Ph.D degree in December 1998. After I joined SUNYSB in the fall of 1997, I have been an active member of SUNYSB Center for Visual Computing (CVC) directed by Professor Arie Kaufman. Within the CVC, I have established an active and interdisciplinary research group on physics-based modeling and its applications. The research group consists of more than ten graduate students within the SUNYSB Center for Visual Computing. Throughout each year, our research group meet every week and have our own seminar series every Monday (Seminar on Geometric Modeling and Physical Simulation) that is also officially listed in SUNYSB course book and open to all graduate students on the campus. Most of the group members are my Ph.D. students. So far, among all the doctoral students whom I had or have supervised during the last eight years, seven Ph.D. students have finished their doctoral studies and successfully defended their dissertations. They are:

- **Chhandomay Mandal (Ph.D., December 1998, University of Florida)**, Dissertation title: A Dynamic Framework for Subdivision Surfaces, Current position: senior research engineer, Sun Microsystems, Inc.

- **Ye Duan (Ph.D., June 2003)**, Dissertation title: Topology Adaptive Deformable Models for Visual Computing, Current position: assistant professor of computer science, University of Missouri at Columbia.

- **Kevin T. McDonnell (Ph.D., August 2003)**, Dissertation title: DYNASOAR: DYNAmic Solid Objects of ARbitrary topology, Current position: assistant professor of computer science, Dowling College.

- **Haixia Du (Ph.D., March 2004)**, Dissertation title: PDE-based Geometric Modeling and Interactive Sculpting for Graphics, Current position: research scientist, National Institute of Health (NIH).

- **Jing Hua (Ph.D., June 2004)**, Dissertation title: DIVE: Dynamic Inhomogeneous Volumetric Environments for Graphics and Visualization, Current position: assistant professor of computer science, Wayne State University.

- **Hui Xie (Ph.D., August 2004)**, Dissertation title: Surface Design and Reconstruction Techniques in Computer Graphics, Current position: research scientist, Siemens Research Corporation.

- **Yu-Sung Chang (Ph.D., June 2005)**, Dissertation title: Multiresolution Solid Objects on Simplicial Complexes, Current position: research scientist, Wolfram Research, Inc.

In May 2006, I anticipate that two more Ph.D candidates in my research group will defend their dissertations and complete their doctoral studies under my supervision. They are: **Ying He (Ph.D., May 2006, expected)** and **Xiaohu Guo (Ph.D., May 2006, expected)**. Through the graduate advising, I have been able to contribute to the development of highly qualified personnel for the benefit of U.S. education, IT industry, and the economy. It may be noted that among the seven Ph.Ds listed above, three are working in academia (Professor Ye Duan, Professor Kevin T. McDonnell, and Professor Jing Hua), three are working in industry (Dr. Chhandomay Mandal, Dr. Hue Xie, and Dr. Yusung Chang), and one is working in government agency (Dr. Haixia Du at NIH). In late 2006 or early 2007, I also expect that at least one other student in my research group will complete his dissertation research.

In addition, I was also advising several M.S. students in our department (11 M.S. students whom I advised have graduated during last eight years):

- Francesco Gallarotti (June 2005);
- En-Kuang Frank Liu (December 2004);
- Matt Richardson (August 2003);
- Qinhong Pan (December 2000);
- Tao Wang (December 2000);
- Honglei Zhang (December 2000);
- Juan Ramirez (June 1999);
- Vivek Palan (June 1999);
- Chhandomay Mandal (May 1997, at UFL);
- Ed Porras (May 1997, at UFL);
- Chris Gilmore (May 1997, at UFL).

Among all the research assistants (RAs) in the department of computer science, during the last four years, I have been supporting six RAs through my research grants. This number is much higher than the departmental average per faculty member. More importantly, through my academic supervision and their hardworking, my students have started to publish their research papers at the second year of their graduate studies. I anticipate that they will become more productive in the years to come, and this will significantly enhance the SUNYSB-CS visibility in our research community. In addition to graduate advising, I also contribute to the development of human resources by encouraging our undergraduate students to actively take part in graduate research through sponsored programs (especially through some of my research projects sponsored by NSF).

Furthermore, I have been participating in thesis committee work of many other Ph.D and M.S. students. Through my active involvement in academic advising, I am able to promote fruitful interactions between my students and myself and effectively train them to gain independent problem-solving skills towards obtaining their advanced degrees. Meanwhile, I also supervised senior undergraduate students to work on research projects both at UFL and SUNYSB.

Undergraduate Research

In all the CS undergraduate courses I taught during the last ten years, I always tried to present the latest research advances in relevant fields at the end of each semester (if time permits), motivating undergraduates towards graduate studies and aiming to the effective integration of undergraduate education and research. Meanwhile, I also allowed the top-quality undergraduate students to take my graduate courses if they did have strong interest in pursuing this option and have sufficient background in the meantime. My goal is to encourage them to realize their full academic potential and broaden their interest and prepare them for a better professional career in the future. For example, two of the best students in my CSE328 courses in the fall of 1999 actually registered in my CSE530 course in the spring of 2000. At the end of the semester, they received A and A- in CSE530, respectively. I believe that this is also an efficient mechanism to prepare our undergraduate students to effectively conduct research. As a result, I supervised one undergraduate student (Robert A. Wlodarcyzk, who was double-majoring in both computer science and physics) in computer science research in 2000-2001. He collaborated with Dr. Kevin T. McDonnell and worked on the project of Virtual Clay, which was part of my NSF initiatives on physics-based subdivision solids. At the end of this undergraduate research work, Robert was a co-author of our paper on Virtual Clay ("Virtual Clay: A Real-time Sculpting System with Haptic Toolkits," K.T. McDonnell, H. Qin, and R. A. Wlodarczyk, *Proceedings of 2001 ACM Symposium on Interactive 3D Graphics*, Research Triangle Park, North Carolina, March 19-21, 2001, pages 179 – 190.) Because of my leading efforts in several NSF projects, in the near future I am also planning to apply for additional NSF funding through special NSF initiative on Research Experience for Undergraduate (REU) in order to further broaden the accessibility of our research by our undergraduate students in CS department.

University, Public, and Professional Services

I have been actively serving in both university and research communities. Ever since I joined SUNYSB, I have been a member of Computer Science Graduate Admissions Committee during the last eight years. From 2004, I also became the co-Chair of our CS Graduate Admissions Committee. Since the beginning of 2006, I have assumed the position of the Chair of our CS Graduate Admissions Committee. This committee is responsible for graduate student recruiting and fellowship/scholarship selection. Typically, we have roughly 400-600 applications from all over the world for our Ph.D program alone each year. Among all the Ph.D applicants, about 90% are international applicants, and the rest are domestic applicants. In addition, we typically have about 400-700 M.S. applicants each year. During the past five or six years, we constantly have more than 1000 (sometimes near 1200) candidates from all over the world applying for admission into our CS graduate program on a yearly basis. Since CS graduate program at Stony Brook is one of the largest on campus, serving on and chairing the CS Graduate Admissions Committee require tremendous efforts, time, and commitment from its members, mainly because of the heavy workload to handle a large application population each year (e.g., several hundreds of applications for our Ph.D and M.S. programs, respectively). Consequently, I have been working extremely diligently and have been devoting significant efforts and tremendous amount of time to this process in order to ensure that the admitted (Ph.D and M.S.) students are of great quality. As a result of the hardworking of all committee members, we have been extremely successful in attracting top-quality graduate students world-wide. For example, our Ph.D students have been ranked among the top within SUNYSB based on their GPAs and GRE/TOEFL scores.

In addition, in 1998 I was the creator and organizer of the annual departmental event of Computer Science Graduate Student Orientation (which is one-day event right before the start of the fall semester each year) and continued my leading effort in organizing this event successfully for the following two years (in 1998 and 1999). To ensure its continuing success, I also assisted Professor Klaus Mueller (who took over my prior duties and played a leading role in coordinating this event in the fall of 2000) in organizing our Graduate Orientation in 2000. Now this event has becomes one of the most important get-togethers and popular social events in our CS department. Furthermore, I have also served as an examiner for our CS Ph.D qualification exams on the regular basis during the last eight years.

Other university-wide services (that are not documented above) include:

- Member of the Faculty Academic Advisory Group for Chinese-mother-tongue International Freshmen, 2005–present.
- Being a member of our CS Faculty Recruiting Committee in 2000–2001, and 2003–present.
- Being one of the instructors for the campus-wide orientation course (USB101/EAS101) for university freshmen in the fall of 1999;
- Undertaking the academic advising for a group of CS undergraduate students each year under the new, revised departmental advising policy;
- Being one of CS faculty representatives at the College of Engineering and Applied Sciences' graduation ceremony in May 1999;

- Spending time with many local high-school students to discuss and suggest possible research projects for their scientific competitions;

- Helping write one new section (the perspective section for our alumni) of the new Stony Brook Computer Science graduate brochure in 2004;

- Being a Faculty Judge for our Graduate Research Conference several times during the last five years;

- Advising more than ten Ph.D. students;

- Supervising more than ten M.S. students and many more undergraduate students;

- Being a Thesis and Examination Committee Member for more than thirty-five Ph.D. and M.Sc. students (advised by other faculty members) in Departments of Computer Science, Applied Mathematics and Statistics, and Mechanical Engineering (the detailed list of names can be found in my CV);

- Hosting one visiting scholar from China for one year (Professor Tonglin Zhu from South-China Agricultural University) in 2004–2005;

- Supervising one visiting Ph.D. student from Korea for one year (Ms. Seyoun Park from KAIST) in 2004–2005;

- Inviting many prominent researchers to visit our department and labs in order to continue to promote the research visibility of our department and our university in our research community; and

- Meeting with graduate representatives of Computer Science Graduate Student Council (CS-GSC) several times to address issues and offer suggestions on how to improve our annual Computer Science Graduate Research Conference and our weekly departmental seminar series.

In addition to my service within our university, I have also been actively contributing to our research community through a large variety of professional activities as follows:

- **Editorial Board Member** for: (1) IEEE Transactions on Visualization and Computer Graphics, 2005–present; and (2) The journal of The Visual Computer, 2003–present;

- **Conference Chair** for The 23rd International Conference on Computer Graphics (CGI'05), June 8-10, 2005, Stony Brook, New York;

- **Conference Session Chair** for many academic and research conferences in geometric modeling, shape modeling, computer vision, and computer animation;

- **International Program Committee Member** for more than 45 international conferences in geometric modeling, computer graphics, animation, and visualization (please see my CV for the detailed listings);

- **Referee** for major journals, conferences, and textbook publishing corporations (for book review). Note that, I have been serving as a reviewer for more than 30 international journals and more than 40 international conferences during the last eight years (please see my CV for the details);
- **Panel Member** for research proposals at National Science Foundation;
- **External Referee** for Research Council of Norway, National Natural Science Foundation of China, and City University of Hong Kong's Strategic Fund (administrated by its research committee);
- **External Examiner** for the Ph.D. dissertation of Dr. Xuetao Li of National University of Singapore;
- **Award Committee Member** for Best Paper Award Committee of ACM Symposium on Solid and Physical Modeling, June 13-15, 2005, MIT, Cambridge, Massachusetts;
- **Invited Speaker** for seminars on modeling, graphics, and visualization in more than fifty universities, national laboratories, and corporations world-wide (e.g., in U.S., Canada, and P.R. China);
- **Invited Speaker** at several international conferences and national workshops including:
  - Pacific Graphics'2000 in Hong Kong;
  - ARO VPERI Workshop 2005;
  - Workshop on Image Processing and Computer Vision/Graphics, Hangzhou, 2004;
  - International Symposium on Computer Vision, Object Tracking and Recognition, Beijing, 2004;
  - Army High Performance Computing Research Center (AHPCRC) Workshop on Graphics Modeling, Simulation and Visualization, Tallahassee, 2003;
  - The Second International Workshop on Articulated Motion and Deformable Objects (AMDO 2002), Palma de Mallorca, Spain, 2002;
  - the First Chinese Conference on Geometric Design and Computing, Qingdao, P.R. China, 2002.
- **Invited Instructor** for "Advanced Graphics and Visualization: Theory, Algorithms, and Applications," *an advanced graduate course of the Dragon Star Initiative sponsored by National Natural Science Foundation of China*, 2003-2006.

More detailed information about my professional services can be found in my curriculum vitae.

In conclusion, all of the aforementioned activities in research, teaching, and service have provided me the unique opportunity to disseminate knowledge in academic and industrial communities, pursue domestic and international collaborations, and contribute to the development of highly qualified personnel for the benefit of U.S. education, IT industry, and the economy. During the last ten years, I have been working extremely hard and have accomplished significantly in education, research, human resource development, and public and professional service both within SUNYSB and in our research community. In addition, through further advancement in interdisciplinary collaborations, I am aiming to build (upon my previous efforts) long-term cohesive multidisciplinary research programs spanning several departments at SUNYSB, a new effort which promises to further advance the state of knowledge of emerging fields.

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