Computational Science at USCB

Web: [http://www.uscb.edu/csci](http://www.uscb.edu/csci)

Outline

- Computational Science: History and new Perspectives
- The need for Computational Science in SC
- Computational Science at USCB
  - A brief history of our program
  - Faculty and research
  - Courses and curricula
  - Students
  - Connection to community and local industry
  - The future

Computer: a New Point of View

- An integral part of our daily lives
  - Universal tools with multiple capabilities
  - Independent and embedded devices networked with each other for the purpose of education, communications, working, entertainment, and many others

- Original purpose of the computer
  - Computation
Computing: A Brief History of Machines

How can it happen? => Computer Science
Why can it happen? => Computation

From computing machines to Computer Science

- The invention and evolution of the modern digital computer not only built valuable computing tools but also established a foundation for a field of study called Computer Science.
- On the other hand, Computer Science has also shifted traditional computing machines to a more general (or multipurpose) tool—and has even developed computing mechanisms for other science & engineering disciplines.

Computer Science

- Computer Science:
  - The study of the theoretical foundations of information and computation, and of practical techniques for their implementation and application in computer systems.
- Topics
  - Computer systems, Computer applications, Theory and programming languages, Networks, Human computer interactive systems, Artificial intelligence, and Software engineering

Graduates from Computer Science

- May require additional training in order to apply their skills to other science and/or engineering areas
Computer Science to Computational Science (i)

- Computational Science depends on Computer Science
  - Operating systems – interfaces to manage resources
  - Programming languages – tools to transfer problems to computer statements
  - Algorithms and data structures – methods to organize and manipulate data
  - Modeling and simulations – understanding real-life problems

Computer Science to Computational Science (ii)

<table>
<thead>
<tr>
<th>Computer Science (Theory)</th>
<th>Computational Science (Integrate Computer Science with other Science and Engineering)</th>
<th>Other Science &amp; Engineering (Applications)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer systems</td>
<td>Computing infrastructure, Operating systems, Resource management</td>
<td>Aerospace, Biology, Chemistry</td>
</tr>
<tr>
<td>Human computer interaction</td>
<td>Human operating interface, Input and output technologies</td>
<td>Disaster control, Economics, Finance</td>
</tr>
<tr>
<td>Computer applications</td>
<td>Database management, Computer graphics, Image processing, Visualization</td>
<td>Electromagnetics, Fluid dynamics, FORENSICS</td>
</tr>
<tr>
<td>Theory and programming languages</td>
<td>Programming languages, Algorithms, Computing optimization, Benchmarking</td>
<td>Geophysics, Physics, Pattern Recognition, Security and defense, Weather</td>
</tr>
<tr>
<td>Computer networks</td>
<td>Communications, Parallel computing, Grid computing, Mobile computing, Cloud</td>
<td></td>
</tr>
<tr>
<td>Artificial intelligence</td>
<td>Expert system, Fuzzy logic, Neural networks, Genetic algorithms, Control, …</td>
<td></td>
</tr>
<tr>
<td>Software engineering</td>
<td>Software architecture, Software management, Software quality management</td>
<td></td>
</tr>
</tbody>
</table>

Computational Science

- One of Five College Majors on the Rise*


Computational Science is a field of applied Computer Science, in which computing theories and software techniques are used to serve and advance many diverse fields, including science, engineering, social science and business.
The need for Computational Science in the state of South Carolina

Regional Requirements

- Economic development
  - Historically based on agriculture and hospitality/tourism industry

<table>
<thead>
<tr>
<th>Race / Ethnicity (2010)</th>
<th>Beaufort</th>
<th>Colleton</th>
<th>Hampton</th>
<th>Jasper</th>
<th>SC</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>71.9%</td>
<td>57.0%</td>
<td>42.7%</td>
<td>43.0%</td>
<td>68.9%</td>
<td>80.1%</td>
</tr>
<tr>
<td>African American</td>
<td>19.3%</td>
<td>39.0%</td>
<td>53.9%</td>
<td>46.0%</td>
<td>28.1%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>12.1%</td>
<td>2.8%</td>
<td>3.0%</td>
<td>15.9%</td>
<td>4.5%</td>
<td>14.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education (age 25-65, 2005-2009)</th>
<th>Beaufort</th>
<th>Colleton</th>
<th>Hampton</th>
<th>Jasper</th>
<th>SC</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school graduates</td>
<td>90.6%</td>
<td>74.9%</td>
<td>75.3%</td>
<td>72.5%</td>
<td>82.2%</td>
<td>84.0%</td>
</tr>
<tr>
<td>Bachelor’s and higher</td>
<td>36.7%</td>
<td>13.7%</td>
<td>10.9%</td>
<td>10.4%</td>
<td>23.5%</td>
<td>27.5%</td>
</tr>
</tbody>
</table>

Average Weekly Wage (2010, Preliminary)
- Under age 18 in poverty (2009): 20.3% 35.7% 33.9% 34.0% 24.4% 20.0%
- All ages in poverty (2009): 12.0% 22.0% 25.4% 25.3% 17.1% 14.3%


State Requirements

- One of the 10 fastest-growing states in the nation since 2000, with most of the population increase resulting from people moving here from other states

Population Growth Rate

State Requirements (cont.)

- Change of SC employment by occupation from 1999 to 2007
  - Need to create higher paying jobs and contribute to economic growth and diversification
  - Competitive skills of the regional workforce are of prime importance

<table>
<thead>
<tr>
<th>Professional, Scientific, &amp; Technical Services</th>
<th>2002 Employees</th>
<th>2007 Employees</th>
<th>Change</th>
<th>% Change</th>
<th>2006 Establishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Carolina</td>
<td>60,500</td>
<td>73,500</td>
<td>13,000</td>
<td>21.6%</td>
<td>12,223</td>
</tr>
<tr>
<td>United States</td>
<td>6,648,800</td>
<td>7,662,000</td>
<td>1,013,200</td>
<td>15.2%</td>
<td>944,448</td>
</tr>
</tbody>
</table>

Source: U.S. Department of Labor, Bureau of Labor Statistics
Meeting regional and state needs

- The Computational Science program at USCB is the first of its kind in the state.
- We are uniquely positioned to:
  - Prepare graduates to compete for technology-oriented positions.
  - Provide service to the region, local military bases, and the Marine Corps Air Station.
  - Build a path for regional high-school graduates to continue education in computing and engineering fields.
  - Prepare students for graduate studies in computing.
  - While graduate programs are plentiful nationally, undergraduate education in Computational Science is not common.

Unprecedented demand for graduates who can program high-performance parallel computing systems

- Increase in the domestic HPC workforce is essential for US to stay competitive in supercomputing.
- “Most computer science programs do not offer classes in [high-performance computing] at the undergraduate level…” —HPCwire, 1/3/2012

A Brief History

- Spring 2007 – initial idea for a new program in Computational Science.
- 2007-2009 – grant/program application process.
  - 2007-2008 – various grant proposals to NSF.
  - USCB Faculty Senate.
    - Full proposal approved on Sept 18, 2009.
  - USC Board of Trustees full proposal approved on Oct. 16, 2009.
  - CS-CHE (South Carolina Commission on Higher Education).
    - Full Proposal approved on Feb 4, 2010.
  - SACS (Southern Association of Colleges and Schools).
    - Full proposal approved on July 30, 2010.
- July 2009 – received support from NSF EPSCoR [link].
- Aug. 2010 – program implementation at USCB.
- 2010-2011 – workforce development and student recruiting.
Our courses and curricula are aligned with our program mission:

- To train a new generation of knowledge workers in computational thinking, applied programming, and high-performance computing
- To provide a unique and challenging undergraduate degree offered at only a handful of schools in the United States
- To improve the technology workforce in South Carolina by identifying local and regional career opportunities for our students

Practical Issues for Courses in Computational Science

- Traditional computing education/research in science
  - Basic computing and programming education
- New interdisciplinary, collaborative approach
  - Computing theory + One science/engineering subject
  - Strike a balance for combined knowledge in more than one field

Learn from Others’ Best Practices

- Major courses similar to other institutions
  - Computational tools
  - High-performance computing
  - Applied and computational methods
  - Simulation and modeling
  - Visualization
  - Computer applications

Courses at USCB

- Courses and descriptions are given on our homepage (http://www.uscb.edu/csci)
  - Special focus on:
    - Algorithms & Data Structures, Database systems and Data mining, Graphics and Visualization, Communication networks, Modeling and simulations, and High performance computing
  - Students are also required to select cognate courses from other programs, such as:
    - Biology/Computational Biology
    - Computational engineering
    - Management information systems

Collaboration with Other Sciences

- Cognate courses
  - A cognate consists of twelve credit hours, chosen through advisement, from outside the major. The courses are required to be above the prerequisite level and may be distributed over more than one subject area.
- Elective courses:
  - As part of this degree, it is important to have a strong science core to fulfill the major concentration requirements. All elective courses are drawn from the list of major requirements for the majors in their respective fields.

Uniqueness

- Emphasis on:
  - Math: Linear Algebra, Statistics, and Calculus I-III
  - Computing courses: Computational Tools, High performance Computing, Simulation, and Computational Mathematics
  - Interdisciplinary collaboration
  - Student centered education
    - Small classroom setting
    - Students select their own concentration, and they determine their major courses with mentors

Our students

- Program enrollment: about 35 students and growing
  - Significant participation from females (15%) and minorities (30%)
  - First class of CSci graduates expected in 2013
- First-year to second-year retention at around 90%
- Our students are doing great:
<table>
<thead>
<tr>
<th>GPA</th>
<th>Percentage of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;=2.5</td>
<td>71%</td>
</tr>
<tr>
<td>&gt;=3.0</td>
<td>41%</td>
</tr>
<tr>
<td>&gt;=3.5</td>
<td>18%</td>
</tr>
</tbody>
</table>
Challenges for Our Students

- Finance is still a big problem:

<table>
<thead>
<tr>
<th>2010-2011 Award Year</th>
<th>Average Amount</th>
<th>Percentage of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Need</td>
<td>$10,787</td>
<td>55%</td>
</tr>
<tr>
<td>Pell Grant</td>
<td>$3,801</td>
<td>45%</td>
</tr>
<tr>
<td>Student Loan</td>
<td>$6,690</td>
<td>40%</td>
</tr>
<tr>
<td>Parent Plus Loan</td>
<td>$12,100</td>
<td>10%</td>
</tr>
<tr>
<td>LIFE Scholarship</td>
<td>$4,375</td>
<td>20%</td>
</tr>
<tr>
<td>Hope Scholarship</td>
<td>$2,500</td>
<td>5%</td>
</tr>
</tbody>
</table>

- USCB offers academic computing scholarships for new students [link].
- We are also working on grant proposals through NSF.

Voices of Students

- Sean Binkley
- Brian McClure

Classroom and laboratory facilities

- Instructional lab for exclusive use by CSci students
  - Dell OptiPlex desktop computers (17 Windows + 5 Ubuntu Linux)
  - 3 Apple iMacs
- Laptop-equipped classroom
- Faculty research computing lab
  - with 2 high performance workstations, with Intel Xeon dual quad-core (or six-core) processors and NVIDIA GPU
- Coming soon: Videoconferencing-equipped classroom

Connection to Community and Industry

- Local High Schools
  - HHI High School (Dual enrollment)
  - Jasper High School (Teacher training program)
  - Bluffton High School (Dual enrollment)
  - Richland County School District One (Aerospace Career Awareness Day)
  - SC Governor’s School for Science and Mathematics
- Internship opportunities with local employers
  - CareCore National
  - Savannah River National Laboratory
  - Lang Mekra (http://www.lang-mekra.com/)
  - Great Dane
  - …
Reaching out to students, the community, and the world

www.facebook.com/CSci.at.USCB

Faculty and Research

- Dr. Yiming Ji, Auburn University, 2006
- Dr. Brian Canada, Pennsylvania State University, 2010
- Dr. Xuwei Liang, University of Kentucky, 2011

See faculty webpage

Research – Ji

- Computational methods for simulation of flow over aircraft and the design of the aircraft (airfoil/wing, body, and overall aircraft) (1995-2000)
- A little bit of image processing (2002-04)
- Wireless sensor networks (2004 - now)
  - Indoor sensor networks
    - 3D indoor radio propagation model for radios at 433MHz and 2.4GHz.

Research – Ji (Cont.)

- Signal propagation in a building
  - Localization, Performance in meters
  - Indoor sensor networks

Classification of satellite images
Research – Canada

- Zebrafish Phenome Project (2006-present)
  - Automated analysis & labeling of zebrafish histological abnormalities (mutant phenotypes)
  - Deep mining of phenotype data to infer function of novel genes
  - Member of LAMHDI working group (NIH/NCRR) since 2010
- SC Project on Organ Biofabrication (2011-present)
  - Computational morphometric analysis for classification of vascular networks
  - Adjunct professor in Dept. of Regenerative Medicine @ MUSC

Research – Canada (Cont’d)

- Citizen science & crowdsourcing (2010-present)
  - Public involvement in Zebrafish Phenome Project via "serious gaming"
  - Pixel classification of grassroots "balloon maps" (from 2011 CSci Image Processing Workshop)
- Local ecology (2011-present)
  - Dune vegetation analysis w/D Dr. Stephen Borgianini (Prof. Biology) and Sarah Ludwig-Monty (USCB class of 2011)
  - Bioacoustic analysis of fish sounds w/Dr. Eric Montie
- Other projects:
  - "Big Data" in the tourism industry (w/Dr. John Salazar)
  - "Computational creativity"
  - Robotics & HCI for improved accessibility

Research – Liang

- DTI (a kind of MRI)
- Human brain neural system
- Alzheimer’s disease, schizophrenia, and multiple sclerosis

Research – Liang (Cont.)

- TUMOR
Student Research

- Summer research program
  - Approx. 10 students participate in the program annually
- 3~5 undergraduate research assistants per faculty member
  - Robert Player: Magellan Scholar 2010-2011, by U. of SC
  - Jonathan Bello-Mejia: one of 45 students selected from more than 400 applicants for Distributed Research Experiences for Undergraduates, by NSF
- Publications:
  - Austin Canfield (with Dr. Ji). One paper in the 4th IEEE International Conference on Computer Science and Information Technology, Chengdu, China, June 10-12, 2011. (Acceptance rate: 28%).

Career prospects for USCB CSci Graduates

Careers for BS Graduates in Computational Science

- Graduate schools
  - Any interested disciplines (including Computer Science)
- Any disciplines in science, technology and engineering
  - Corporate organizations
    - AT&T laboratories
    - Bell labs
    - Boeing company
    - Internship and Career information at SIAM: http://www.siam.org/careers/internships.php
  - Government and non-profit institutions
    - Aerospace corporation
    - Air force office of scientific research
    - National Aeronautics and Space Administration
    -...

More info on our program webpage:
http://www.uscb.edu/csci (then click on “Links”)

Job Growth Trend

- Related job growth in Computer/Computational Science

<table>
<thead>
<tr>
<th>Job title</th>
<th>Job growth (10-year forecast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telecommunications Network Engineer</td>
<td>53%</td>
</tr>
<tr>
<td>Systems Engineer</td>
<td>45%</td>
</tr>
<tr>
<td>Business Analyst, IT</td>
<td>29%</td>
</tr>
<tr>
<td>Applications Systems Analyst</td>
<td>20%</td>
</tr>
<tr>
<td>Software Developer</td>
<td>28%</td>
</tr>
<tr>
<td>Software Product Manager</td>
<td>28%</td>
</tr>
<tr>
<td>Computer Software Program Manager</td>
<td>28%</td>
</tr>
<tr>
<td>Business Management Software Consultant</td>
<td>28%</td>
</tr>
<tr>
<td>Senior Software Test Engineer</td>
<td>28%</td>
</tr>
<tr>
<td>Software Architect</td>
<td>28%</td>
</tr>
<tr>
<td>Software Development Director</td>
<td>28%</td>
</tr>
<tr>
<td>Computer/Network Security Consultant</td>
<td>27%</td>
</tr>
<tr>
<td>Computer and Information Scientist</td>
<td>22%</td>
</tr>
<tr>
<td>Information Technology Project Manager</td>
<td>16%</td>
</tr>
<tr>
<td>Senior Web Designer</td>
<td>15%</td>
</tr>
<tr>
<td>Help Desk Manager, IT</td>
<td>13%</td>
</tr>
</tbody>
</table>

Web Source: http://www.siam.org/careers/internships.php
Today’s Job Market

- Jobs are there, qualified applicants aren’t
- Several job sectors need more qualified applicants

“More than one-third of Human Resource managers we surveyed said they currently have positions for which they can’t find qualified candidates, a trend that continues to grow as the economy recovers and job prospects improve,” said Matt Ferguson, CEO of CareerBuilder.

<table>
<thead>
<tr>
<th>Hiring Trouble</th>
<th>Openings</th>
<th>Hires</th>
</tr>
</thead>
<tbody>
<tr>
<td>All part-time employees</td>
<td>20</td>
<td>43</td>
</tr>
<tr>
<td>Finance</td>
<td>38</td>
<td>60</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>43</td>
<td>60</td>
</tr>
<tr>
<td>Arts, entertainment</td>
<td>41</td>
<td>60</td>
</tr>
<tr>
<td>Professional and business services</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>Education and health services</td>
<td>43</td>
<td>60</td>
</tr>
<tr>
<td>Government</td>
<td>44</td>
<td>60</td>
</tr>
<tr>
<td>Leisure and hospitality</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>Trade, transportation, and utilities</td>
<td>46</td>
<td>60</td>
</tr>
</tbody>
</table>

Source: NA analysis of labor department data

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Help us to enable our students’ future!