AC 2011-1061: ENCOURAGING ART AND SCIENCE CROSS-DEPARTMENTAL COLLABORATION THROUGH AN INTERDISCIPLINARY PROGRAM

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Encouraging Art and Science Cross-Departmental Collaboration through an Interdisciplinary Program

Abstract

The impact of computational algorithms on many art disciplines outside the arena of mathematics, engineering, and technology has been no less than profound. This impact especially applies to biology and criminal justice, two disciplines which have benefited immensely from the advances in computer technology at both the hardware and the software sides. Drawing on the strengths of the Criminal Justice, the Biology, and the Computer and Information Sciences Departments, a new undergraduate degree in computational science has been created (after going through department, college, and state approval processes) for the first time at the institution, and became available to student starting fall of 2010. Heeding the national educational and curricular calls to create new programs that enhance employment chances of college and university graduates, our degree aims at graduating the next generation of students, who are well-versed in the design, application, and understanding of computational algorithms as they apply them to their specific areas of specialization. The new degree allows for future inclusion of other areas/tracks that are proving daily to be more inter-disciplinary and computationally intensive such as biochemistry, nanotechnology, and neuroscience. This paper chronicles our efforts in creating the computational science program and the details of the offered degrees, the required courses, and the learning outcomes expected of future graduates of the program.

Keywords
Art and Science Education, Interdisciplinary Studies, Computational Science, Digital Forensics, Bioinformatics.

Introduction

The continuing advancements in electronics, engineering, mathematics, and computer science have created parallel advancements in biology, forensics, and social networking, among many other areas. These traditionally non-computational areas have been taking advantage of the newly available scientific databases, computing power, and sophisticated software algorithms. Because of the technology influence on these fields, they are becoming more inter-disciplinary in nature and many educators have called for the creation of new programs and degrees that reflect this new reality. Heeding the call for such programs and degrees, the Computer and Information Science department (CIS) at the University of Texas at Brownsville, in collaboration with the Criminal Justice and Biology departments, has lead the effort of creating a new program/degree of a Bachelor of Computational Science that allows for different tracks of specialization. At the heart of the degree is a core of computer science courses that lay the foundation for solid programming and software development skills that enrolled students in the program will attain. In addition, students in the program are allowed to specialize in one area which is outside the traditional "Science and Engineering" Fields. As of today, the degree allows for specialization in Digital Forensics or Bioinformatics, with the possibility for adding other specialization in the

future as institutional resources allow. The following sections detail the different phases that the new program has gone through.

Curriculum Development

The two initial fields (tracks) selected for the Bachelor of Computational Science outside of computer science were digital forensics and bioinformatics. There is no doubt that computing enhances forensics and biology and biology and forensics "enliven computer science" [9]. The two field are also among the most declared majors for bachelor's degrees at our university [1] and attract a large numbers of males and females the majority of whom are Hispanics. In designing the track, several references [2-10] have been consulted to decide the courses and their learning outcomes. We also made sure that the new program will be in compliance with our recently granted ABET accreditation.

Core Computer Science

Table 1 shows the required core that all students in the program must take. This reduced core, compared to traditional and exclusive computer science degrees, makes sure that the student the necessary skills to be a critical thinker with good mathematical and computer skills. The main area where courses were reduced to accommodate the new tracks are in the technical electives that students usually take in their senior year. Our rationale was to make sure that the foundation courses stay intact which would allow any student to build on this foundation as they graduate and continue acquiring knowledge outside an educational institution.

Table 1 Science/CIS Requirements

Science/Computer Science Requirements		
Prefix and Number	**Required Courses**	**SCH**
MATH 2318	Linear Algebra I	3
MATH 2413	Calculus I	4
MATH 2414	Calculus II	4
MATH 3381	Statistics	3
COSC 1336	Programming Fundamentals I	3
COSC 1337	Programming Fundamentals II	3
COSC 2310	Discrete Structures	3
COSC 2312	Digital Logic	3
COSC 2325	Machine Language and Computer Organization	3
COSC 2336	Programming Fundamentals III	3

COSC 3345	Algorithm Analysis	3
COSC 4313	Computer Networks	3
COSC 4342	Database Management Systems	3
	Senior Project	1

Digital Forensics

The field of Digital Forensics is among the most growing in the nation. Unfortunately, the integration of computer science into crime forensics has not been fully appreciated by many educational institutions. Additionally, because of the lack of resources, crime forensics has been largely limited to law enforcement organizations. By introducing the Computational Science degree, a unique and one of a kind degree in the nation, our goal is to graduate future workforce that would support the rapidly growing field of computer and network forensics. The following diagram shows the digital forensic track as it was proposed at the time of the creation of the degree.

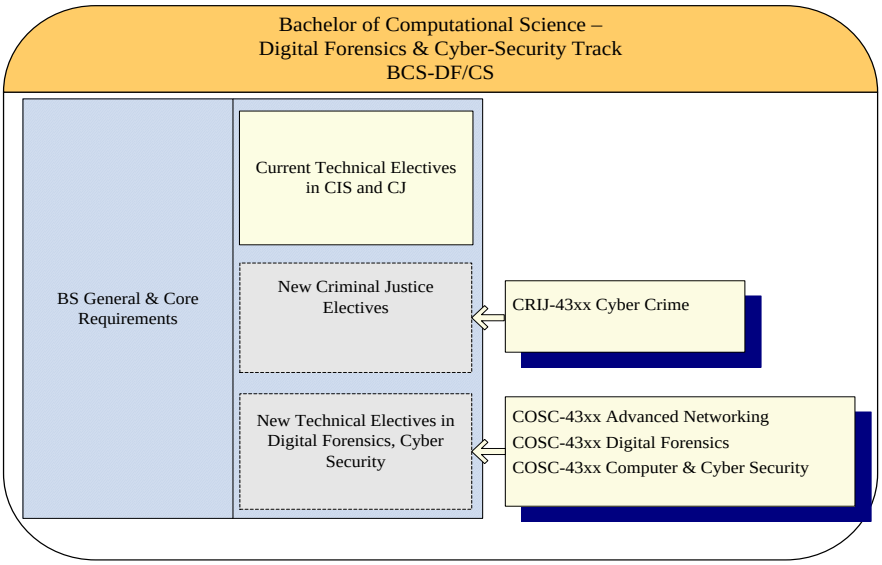

Figure 1 CIS/Forensics New Degree

Tables 2 and 3 show the overall requirements of the degree. A close inspection of the table show that, beyond the core requirements, the required courses are split equally between computer science and criminal justice. It also shows that a new set of courses were created to implement the new degree in an effective way. The set of new courses are Advanced Networking, Digital Forensics, and Computer and cyber Security. These courses integrate computer science and forensic by creating expert knowledge in digital forensics.

Table 2 New Degree Requirements (Forensics Track)

Degree Requirements by Category		
Prefix and Number	Required Courses	SCH
General Core	General Core	48
COSC	Computer Science	51
CJ	Criminal justice	25
	Total	**124**

Table 3 Criminal Justice Degree Requirements

Criminal Justice Requirements		
Prefix and Number	**Required Courses**	**SCH**
	Criminal Law	3
	Forensics Investigation I	3
	Forensics Investigation II	3
	Evidence for Forensic Investigation	3
	Seminar Forensic Investigation	3
	Seminar Forensic Investigation (Different Topic)	3
	Principles of Law Enforcement Supervision	3
	CJ Electives	3
	Cyber Crime	3

Bioinformatics:

As the science that is has the greatest potential of impacting our future way of living--including health, medicine, prevention-- Bioinformatics is one of the fields that benefitted the most from the advancements in computational power (for example, mapping the human genome would have taken a longer period of time has it not been for such advancements). With the potential to impact our lives in amazing ways, the advancement of bioinformatics through advanced algorithms and the application of mathematical modeling has become one of the most active areas of research. With this research comes the need for unique hybrid students who understand both fields in depth and can contribute to new and innovative ways of tackling any challenges as they come up. The Bioinformatics track of Computational Science degree has been designed to produce students who would support this rapidly growing field. The following diagram shows the digital forensic track as it was proposed at the time of the creation of the degree.

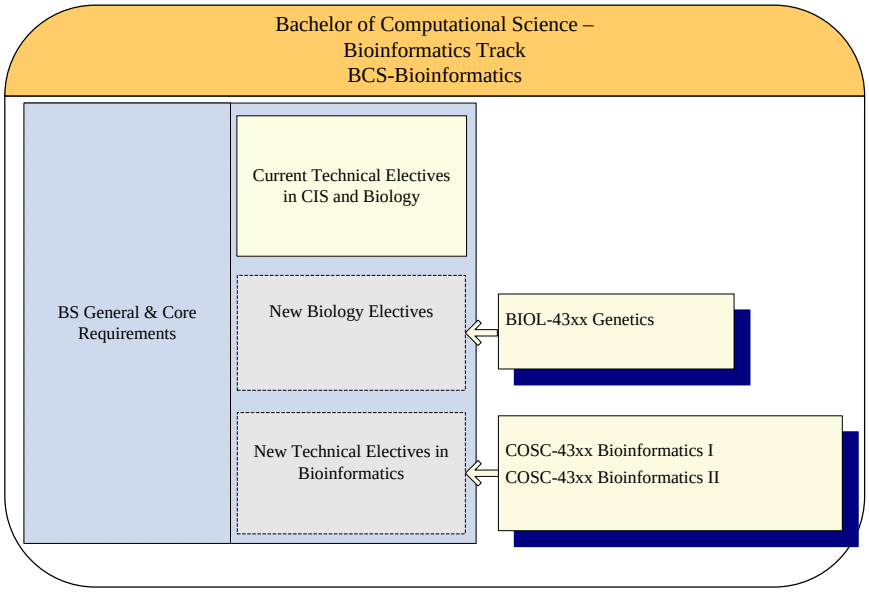

Figure 2 CIS/Bioinformatics New Degree

Tables 4 and 5 show the overall requirements of the degree. A close inspection of the table show that, beyond the core requirements, the required courses are split equally between computer science and Biology. The tables show that a new set of courses were created to implement the new degree in an effective way. The set of new courses are Bioinformatics I and Advanced Bioinformatics. These courses integrate computer science and biology, thus creating expert knowledge in bioinformatics.

Table 4 New Degree Requirements (Bioinformatics Track)

Degree Requirements by Category		
Prefix and Number	Required Courses	SCH
General Core	General Core	48
COSC	Computer Science	51
BIOL	Biology	25
	Total	**124**

Table 5 Bioinformatics Degree Requirements

Criminal Justice Requirements		
Prefix and Number	**Required Courses**	**SCH**
	Biology I/ Lab	4

	Biology II/ Lab	4
	Genetics/ Lab	4
	Cell and Molecular Biology/ Lab	4
	Evolution	3
	Chemistry I	3
	Chemistry II	3
	BIOL Electives	6

Course Description and Learning outcomes

The following list, details the courses' content and their expected outcomes.

Name & Number: COSC 4315 Advanced Networking

Course Description: This course covers the design of networks and their performance. Modern networks such as ATM and Gigabit Ethernet network will also be studied. Other topics that will be studied are cryptology, network programming, and secure channels. Prerequisite(s): COSC 4313, or consent of instructor. Lec 3, Lab. 1, Cr. 3.

End-of-Course Outcomes:

1. Understand common barriers to network security and the major issues involved in implementing proper security measures.
2. Summarize the strengths and weaknesses associated with different approaches to security.
3. Describe the purpose of encryption and the function of public and private keys.
4. Compare and contrast the various types of firewalls and their implementation.
5. Describe the main characteristics of mobile IP and their use in email and other traffic.
6. Explain the issues for network management arising from a range of security threats, including viruses, worms, Trojan horses, and denial-of-service attacks
7. Develop a strategy for ensuring appropriate levels of security in a system designed for a particular purpose.

Name & Number: COSC 4318 Digital Forensics

Course Description: An introduction to the science, technology, procedures, and laws of acquiring and analyzing evidence from digital media and computing devices. Current forensics tools will be surveyed, and case studies will be assigned and presented in class. Prerequisite(s): COSC 4313, or consent of instructor. Lec 3, Lab. 1, Cr. 3.

End-of-Course Outcomes:

1. Follow correct procedures when collecting and handling digital evidence.
2. Apply computer science skills to access, analyze, and interpret digital evidence.
3. Exercise ethical and legal behavior when examining digital evidence.

4. Work with law officers and criminal justice professionals in a team environment.
5. Document and report findings on digital evidence analysis properly.

Name & Number: COSC 4319 Computer and Cyber Security

Course Description: This course is an in-depth study of computer systems and network security principles. Key areas include network attacks and defenses, operating system flaws, malware, social engineering attacks, and digital rights management. Prerequisite(s): COSC 4313, or consent of instructor. Lec 3, Lab. 1, Cr. 3.

End-of-Course Outcomes:

1. Explain the objectives of information security systems.
2. Understand the basic categories of threats to computers and networks.
3. Explain the importance and application of confidentiality, integrity, and authentication in information systems.
4. Understand Intrusions and intrusion detection.
5. Discuss the fundamental ideas of cryptography including private- and public-key cryptography works.
6. Summarize common authentication protocols.
7. Summarize the strengths and weaknesses associated with different approaches to security.
8. Defend the need for protection and security, and the role of ethical considerations in computer use.

Name & Number: CRIJ 4329 Cyber Crimes

Course Description: This course provides an overview of the actors, motives and methods used in the commission of computer-related crimes, and describe the methods used by organizations to prevent, detect, and respond to these crimes. This course focuses on the different types of crimes and the nature of crimes that are committed using computers.

Prerequisite(s): CRIJ 2316, or consent of instructor. Lec 3, Lab. 1, Cr. 3.

End-of-Course Outcomes:

1. Identify various forms of cyber terrorism and their criminological motivations
2. Understand different aspects of computer and internet law as a governing factor in online communication.
3. Understand and explain the detection, collection and preservation of digital evidence (digital forensics) as preparation for legal combined proceedings.
4. Develop an awareness of future of cyber crime and the efforts of the criminal justice system to control it.

Name & Number: COSC 4380 Bioinformatics

Course Description: An introduction This course will provide an introduction to the rapidly evolving field of Bioinformatics with the over arching goal of understanding how Computer Science plays an integral part both in application and algorithmic aspects. Prerequisite: COSC 4342, or consent of instructor. Lec 3, Lab 1, Cr 3.

End-of-Course Outcomes:

1. Have developed a basic understanding of lab and research techniques using molecular biology methods.
2. Have developed an understanding of computational methods used to address problems in molecular biology.
3. Use existing available computational tools for solving problems in molecular biology.
4. Have become knowledgeable about the storage, retrieval, sharing and use of biological data, information, and tools.
5. Have become knowledgeable about how and where to obtain access to online resources for Bioinformatics.

Name & Number: COSC 4381 Advanced Bioinformatics

Course Description: An introduction to the physical and computational principles of medical imaging systems. Topics covered include fundamentals of x-ray radiography, x-ray computed tomography, ultrasound imaging and magnetic resonance imaging. Current techniques for visualization, segmentation, and analysis of medical image data will also be discussed. Prerequisite: COSC 2336, or consent of instructor. Lec 3, Lab 1, Cr 3

End-of-Course Outcomes:

1. Demonstrate a strong grasp of the basic physical principles underlying several medical imaging modalities.
2. Demonstrate a solid understanding of the concepts of medical image acquisition, image formation and display methods.
3. Apply the concepts learnt in class to solve problems in medical image reconstruction, image processing and analysis.
4. Demonstrate an appreciation for the strengths and weaknesses of various imaging modalities and what kind of anatomical and physiological information can be obtained from them.

Each of the courses has a strong laboratory component to provide hands-on experience for the student in a realistic setting. The CIS department has a state of the art networking lab which, along with CJ forensics lab, will be pooled together to provide hardware and software resources for the classes.

Course Development and Offering

To ensure that students are able to complete their course requirements within one to four years depending on the degree they are pursuing, the Criminal Justice, Biology, and Computer and Information Sciences departments follow a system whereby all courses are offered in a predictable rotation. Using this system, the department has added the new courses to its rotation

cycle. To ensure timely graduation for the majors, all chairs have agreed to offer these courses within the first four years.

It is worth mentioning that the CIS department has created a memorandum of understanding with several research university to accept our student in the their graduate programs upon completion of their undergraduate degree if they elect to pursue graduate studies. This pipeline encourages students to pursue the proposed degree in a timely fashion.

Institutional Commitment

Dr. Iglesias, CIS chair and co-author, was the architect behind creating a bachelor of computational science to create the program presented in this paper. All involved deans have expressed their unwavering support for the program and are in helping in every capacity to ensure its success.

Conclusion and Future Work

We truly believe that creating the bachelor of science in computational science with a digital forensics and bioinformatics tracks will pay off in the future as the program matures and comes to fruition. The program offers unique set of skills for its graduates by bridging the gap between traditionally disparate sciences. By wedding computer science to forensics and biology, graduates will have be able to find jobs more easily, and employers will be pleased with the dual knowledge that the employees possess.

Having been active for only one semester, the program is in its infancy and will take some time to mature and attract recruits to its degree. As information about the program is disseminated and the word gets out, we hope to attract substantial number of students, including minorities and females. In a future paper, and as we ascertain more data, we will report on the progress of the program, including challenges, opportunities, achievements, statistics, etc.

References

[1]. "Institutional Data", UTB/TSC Office of Data Management & Reporting, FY 2009.

[2]. Ramsay, J., Cutrer, D., and Raffel, R. (2010), "Development of an Outcomes-Based Undergraduate Curriculum in Homeland Security," Homeland Security Affairs, Vol. 4, No. 2. www.hsaj.org.

[3]. National Academy of Science, (2009), "Strengthening Forensic Science in the United States," Washington, DC: National Academies Pres, (pre-publication version) II-1, http://www.nap.edu/catalog.php?record_id=12589

[4]. The Effects of Computer Science Advancements on Public Health Research Annual Review of Public Health Vol. 6: 325-332 (Volume publication date May 1985) DOI: 10.1146/annurev.pu.06.050185.001545 A T Hunt, P R Morrison, and M Pagano

[5]. Internet Security Lectures Home Page (2004). [Online]. Available: http://www.cs.wright.edu/~pmateti/InternetSecurity/Lectures/Top/lectures.html

[6]. M. Micco and H. Rossman, "Building a cyberwar lab: Lessons learned teaching cybersecurity principles to undergraduates," in Proc. 33rd SIGCSE Tech. Symp. Computer Science Education, Northern Kentucky

[7]. Convention Center, Feb. 2002, pp. 18–22. R. McKemmish, "What Is Forensic Computing," Trends and Issues in Crime and Criminal Justice, no. 118, Australian Inst. of Criminology; www.aic.gov.au/publications/tandi/index3.html.

[8]. C.E. Irvine, S.-K. Chin, and D.A. Frincke, "Integrating Security into the Curriculum," Computer, vol. 31, no. 12, 1998, pp. 25–30. 10. G. Shpantzer and T. Ipsen, "Law Enforcement Challenges in Digital Forensics," Proc. 6th Nat'l Colloquium Information Systems Security Education, NCISSE Colloquium Press, 2002.

[9]. Cohen, J. Guidelines for establishing undergraduate bioinformatics courses. J. Sci. Edu. Tech. 12, 4 (Dec. 2003), 449–456.

[10]. Cohen, J. Bioinformatics: An introduction for computer scientists. ACM Comput. Surv. 36, 2 (June 2004), 122–158.