IMPROVING HBCU UNDERGRADUATE AND GRADUATE COURSE INSTRUCTION ON COMPUTERIZED CONTROL ENGINEERING

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Abstract

There are a number of engineering undergraduate and graduate courses associated with the disciplines of systems and control, signal processing and image processing. The theoretical part is the main component of class instruction. The direction of teaching towards potential real world practical implementation is urgently needed. This article proposes the computerized education in order to enhance HBCU engineering education via engineering practices inside and outside the classrooms. It serves as a multidisciplinary project that will foster HBCU students on learning, innovation and service. Minority student participation will involve across several aspects of the advanced computer technology applications, including literature surveys of journals and conference proceedings, grasping proper laboratory techniques via hands on experience, collecting and analyzing data using computer programs, presenting successful results at international conferences. The redesign and development of lecture and laboratory courses will give rise to improvements on graduate and undergraduate HBCU programs. It will strengthen engineering programs, enhance teaching and research quality.

1. Introduction

Up-to-date technologies in areas of optimization and artificial intelligence should be developed and employed for the enhancement of class instruction and laboratory practical implementation [1-3]. To provide insight and motivation, the course "Fundamentals of EE" has been designed to introduce multiple areas of EE, emphasizing how they are interrelated and how they contribute to the design and functioning of real world applications. The course must be engaged to its students who are evaluating EE as a prospective major and career. To achieve these goals, the course adopts the unifying theme, couples lecture and laboratory exercises, and includes a laboratory experience that emphasizes design, integration, and real applications [4-5]. The interactive classroom lecture and laboratory exercises should be developed iteratively so that each course supports the other, rather than one being dominant for driving the other. Based on specific application of the quality philosophy in development of digital electronics laboratory courses, two main goals are achieved to provide students with a methodology to manage problems and to start a process of continuous improvement [6-7]. Academic workload management is concerned with distributing teaching resources to support educational framework adequately (e.g., faculties, degrees, courses, admission policies, teaching workload). This work presents a methodology for assessing educational capacity and planning its distribution and utilization, implemented as a decision support system allowing simulation and evaluation of various proposals and scenarios. The system integrates input data from relevant sources into an autonomous data warehouse. Graphical client front-end ensures adequate output presentation to decision-makers by revealing significant details and dependencies in the data [1-7].

2. Course Enhancement Necessities

Attracting and retaining high-quality students to HBCU higher education programs is a growing challenge along with the global economy booming. Innovations in teaching aimed at increasing the success rate of more students in higher education are urgently needed. The effective use of engineering technology combined with teaching methodologies has a positive impact on student academic outcomes. Engineering education is a typical area for developing scientific principles for training, applying and disseminating of control engineering technologies and education. Scientific research, course instruction and lab instruction are all conventional approaches that are widely used to distribute these concepts, while hands on computerized pedagogy will optimize the course instruction and student learning. The quality of education for HBCU institutions can be improved significantly using hands on methodologies with improved learning environment, course content, curricula and educational practices. The developed and redesigned lecture and laboratory courses will have a significant impact on all levels of engineering education. Training of more undergraduate and graduate students will lead to attracting potential good quality students from other disciplines. The computerized implementation will enhance practical skills of all our students to have a successful career as an engineer or an engineering faculty in the near future. The newly developed and designed course will make the curriculum both more innovative and effective. These courses will provide students with strong background of theories, algorithms, and practical solutions. Students will gain understanding of algorithm design, mathematical tools and practical implementations via various control applications. They will also learn how to use Matlab, Simulink, C++ and Labview programming languages to implement diverse real world control problems. This involves a mentoring procedure for all students.

The objectives of computerized control engineering education lie in several folds: to create new teaching methodologies for undergraduate courses; to develop faculty expertise on lecture and laboratory course hands on instructing; to assess learning and evaluate innovations by student GPA and comprehensive exams, to conduct research on teaching and learning for HBCU underrepresented students; and to implement educational innovations by integration of instruction and practical implementation. In addition, advanced control engineering education will be applied to the cross-disciplinary engineering education, while an appropriate measure of this objective is quantity and quality of publications (e.g. IEEE, ASME, SAE, ASEE), project outcomes and quality theses. The educational objective is to spark learning and research interests of all participating underrepresented students and to implement theoretical concepts to real world problem solving. In carrying out this objective, educational component will systematically be integrated into research activities. Hands-on computerized experience is important to enhance the concept understanding. The improvement of control engineering courses is intended to provide students with a solid understanding of control theories and control applications. Another potential is to make a design prototype and simulate via human machine interfaces for all potential applications using the programming languages for modeling, control and optimization, which could be a typical example of technology integration between electrical engineering and mechanical engineering. It also provides feasibility of conducting theoretical learning and practical implementation research simultaneously.

3. Redesign and Development of Control Engineering Courses

The redesigned courses are used to implement technical requirements of engineering curriculum. In last few decades, control engineering has expanded its fundamental aspects from the classical control theory, modern control theory to intelligent control theory. The traditional approaches such as PID control, optimal control and adaptive control can be combined with fuzzy control and neural networks to improve the control quality. Computational intelligence is also developed rapidly upon the computer technology explosion, where new artificial intelligence approaches like the evolutionary genetic algorithms, particle swarm optimization algorithms and ant colony optimization have been proposed and applied. All these technologies can also be selected for solving some signal processing and image processing problems. In this case, the course contents in this area must be regularly updated to meet changing needs of most up-to-date technologies and to maintain the cutting edge advances. To help all students obtain a deep understanding of systems and control theories, the integration of theoretical study, theoretical research and practical implementation is important. The redesign of control engineering courses is necessary due to the anxious and increasing demands from all engineering students and the critical research requirements from engineering faculties, undergraduate and graduate students, which will give rise to new research outcomes with academic publications (IEEE, ASME, SAE, ASEE) as well as new prototypes, products and patents. The redesigned courses will involve hands on training to both undergraduate and graduate students, with the focus on concurrent real world problems. The student participation includes: learning proper laboratory techniques; reviewing literatures in professional journals; formulating and planning research directions; analyzing experiment data; preparing results and disseminating to the scientific community. An integration of the theoretical control courses with computer programming may help students to understand theory and develop skills for applications. This leads to discovery across multidisciplinary areas of control science and engineering related to common goals of learning, innovation and service to human society. Students usually enjoy hands-on learning instead of theoretical instruction alone. Thus it will provide a strong interaction between theoretical concepts and practical applications. The classical teaching style is lack of intuitive understanding, which not only makes courses tougher, but also leads to less understanding after examinations. To overcome this type of problems, new material (computer programs, numerical simulations, lab experiments, literature surveys, on-site training, projects and publications) should be introduced to curricula. The planning of course redesign and new course development also supports the goals of ABET criteria for accrediting engineering program and other educational evaluation criteria.

In addition, a new lecture course (Computer Controlled Systems) has been designed, which is to help HBCU students understand deeply the computer control system theories and principles. Classical control, modern control and intelligent control content will be covered to adapt our course instruction to be suitable for the rapid development of control science and engineering discipline within last half century. Various electrical and mechanical engineering control applications will be introduced and some projects will be required to use modeling, control and optimization methodologies to design discrete-time control models for both electrical and mechanical systems. Computerized simulation models will also be introduced for real world problem solving in the senior design projects of our HBCU students. The applications will cover all aspects of control science and engineering. This new course will provide advanced research topics, while computer programming, numerical simulation, control design and implementation will be conducted and integrated. This new course development will strengthen the teaching effectiveness, research outcomes and publications.

To provide students with the hands on experiences, computer software and hardware programs will be made for new control algorithms created by HBCU students. For numerical simulations and on-line real time control applications, the graphic programming language LABVIEW and Matlab, Simulink, C++ and Assembly language programming will be instructed in high level classes, where the user interface will be also designed for practices. It enables the feasibility of conducting research on the control theory and practical implementation simultaneously. For instance, our instrumentation of FEEDBACK servo system consists of three units: Mechanical Unit, Analogue Unit, Digital Unit. The Mechanical Unit is also supplied with 34-way terminated cable and Digital Unit is also supplied with 37-way cable, control software and computer user interface. With the practices using the current Feedback servo system in our new systems and control laboratory, students will benefit not only from the experiments themselves, but also from approaches of integrating new computerized control algorithms (classical control, modern control and intelligent control) into the control experiments.

Taking an example of the robotic control problem, the procedures of robotic integration of smart sensors can be divided into the off-line stage and on-line stage. At off-line stage, numerical simulations are conducted using Matlab, Simulink, Stateflow and C++, etc, where control and optimization approach can be conducted. At on-line stage, real time control approach needs to be developed using LabVIEW and assembly language programming. The students will be instructed and supervised to develop a real-time user interface. It will enhance the capability of operators to control and perceive sensing information precisely and accurately throughout the robotic control. Human-machine interface can be set up by LabVIEW software and hardware, visual interface, haptic interface and other related hardware are needed to support real-time visual and tactile systems. LabVIEW is based on graphical programming. It is integrated fully for communication with hardware such as RS-232 and plug-in data acquisition boards. MATLAB enables the quick testing and multiple alternative comparisons which then produces better solutions. Simulink is an interactive tool for modeling, simulating, and analyzing dynamic systems. It is capable of building graphical block diagrams, evaluate system performance, and refine the preliminary designs. Simulink can be used to simulate continuous and discrete time control systems.

4. Case Study: Placing New Research Areas into Computerized Control Courses

Virtual reality applications are examples of feedback control systems. In general, the virtual reality environment refers to various virtual experiences of vision, through either stereoscopic displays (e.g. LCDs) or computer screens. Stereoscopic viewing enhances both the perception of depth and the sense of space. Some advanced control applications include visual, tactile and audio information simultaneously. Our system focuses on applications of Head Mounted Display (HMD), the vibro-tactile CyberGlove and Computer Automated Virtual Environment (CAVE). Both haptic feedback and visual feedback can be implemented on the virtual reality technology, along with the visual interface and haptic interface. The feedback signals could be the position, orientation, color level and brightness for visual feedback, while the feedback signals could be force, tactile, vibration or pressure information for haptic feedback. Combination of 2 feedback systems will improve the quality of virtual reality. The basic structure for a virtual reality system is shown in Fig. 1.

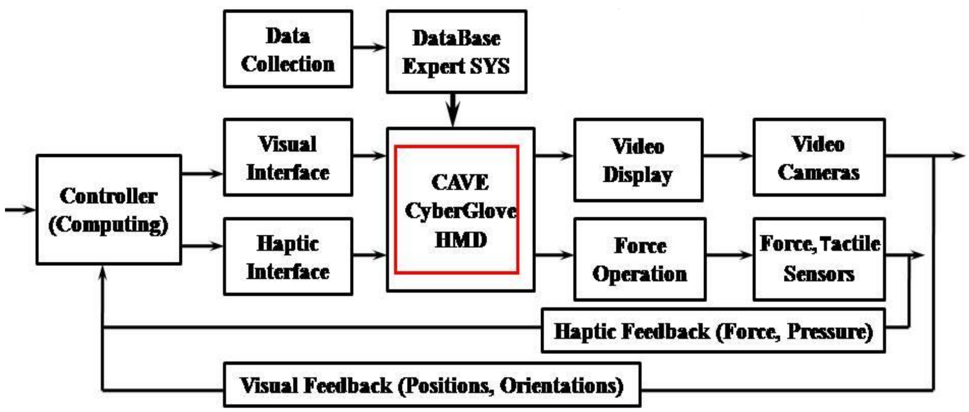

Fig. 1 Principle of Virtual Reality

A. Head Mounted Display (HMD)

The head referenced viewing can provide a natural interface for the navigation in a virtual 3D space which allows for the see-around, walk-around or fly-around capability in the virtual environment. A typical HMD consists of two miniature display screens and one optical system that channels the images from screens to eyes, thus, presenting a stereo view of the virtual world. In fact, both the position and orientation of the objects and HMD will be continuously measured by the motion tracker so that it allows the image generator to adjust the scene to the real time actual view. The HMD can be used to view a computer generated image that superimposes on the real world scene by the partially reflective mirror. Using this system design, people are able to walk through the surrounding virtual environment.

B. CyberGlove Technology

The CyberGlove is suitable for dexterous manipulation tasks. CyberGlove adds tactile feedback actuators to all fingertips of the glove. When fingers of the virtual hand interact with virtual objects, the host computer sends commands needed to activate the vibro-tactile actuators. It has the ability to provide feedback to individual fingers when a contact is made at the finger tips. The haptic feedback gives people the impression of vibrations on the skin via the pulses or vibrations.

Multiple actuators can be excited at that same time to generate complex tactile feedback patterns with the compact structure. It greatly increases the freedom of motion. One example of the CyberGlove system is shown in Fig. 2.

Fig. 2 Virtual Feel Using CyberGlove

C. Computer Automated Virtual Environment

Advanced visualization can be achieved using the immersive virtual reality from the CAVE facility. The CAVE system at College of Engineering is one of five Windows 2000 CAVEs worldwide, whose equipment and software provide an illusion of immersion by projecting stereo images on the front-projected floor and rear-projected screen walls of a room-size cube. It serves as the walk-in visualization environment which can hold several people who can enter and walk freely in a floating virtual 3D real time environment. VR also permits people to vary the values of corresponding variables in order to verify the consequences of these changes in virtual environment, while at the same time, the actual perspective is maintained. The head mounted tracking and display systems can adjust the stereo projection continuously to the current position of the leading viewer. The human machine interface of CAVE provides the drag and drop capability which leads to a short learning period for students. Data from typical engineering hardware and software tools (e.g. Matlab, Simulink, Labview, AutoCAD, etc) can be viewed in this CAVE system. Generally, VR uses an optical illusion technique based on intentional image distortion to generate stereoscopic vision. Educators, students and researchers can visually interact with simulation or experiment data together in real time 3D displays by wearing stereo glasses and viewing data. Using these special stereoscopic displays inside the CAVE, the people are fully immersed. Images appear to float in space so that people are free to walk around but maintain a proper perspective. The data fusion and visual analysis software tool is used to support the data exploration, knowledge discovery and visual display. For instance, CAVE allows people to access different functionalities on datasets of geospatial intelligence systems. It can also be used to convert and track the information from the global positioning system.

D. Augmented Reality Applications

As discussed above, using virtual reality, people are totally isolated from the real world while completely immersed into the artificial world. In other words, there is no interaction between the real world and artificial world. Thus, another new technology can be introduced, which overlays the virtual artifacts onto the real environment. The augmented reality provides straightforward ways to interact between the virtual scene and real world to enhance the visual scene: either fill the virtual artifact into the real environment or display additional information about the existing real objects. AR brings people with the real world via employing people's own visual and spatial skills. The computerized system serves as working environment of people with the combination of the real scene and virtual scene. It can be applied to the 2D images and 3D objects. In general, the images can be captured by CCD cameras, spectroscopic devices and ultrasound arrays, etc. The stereoscopic 3D illusion is generated from a pair of 2D images and then reconstructed by the computer, which produces stereo views. AR allows people to examine real 3D objects and simultaneously receive additional artificial information. To implement the augmented reality, 3D graphic models of various objects are overlaid on the actual video scene. Once the position and orientation is known, an AR scene is generated. The enhanced real-time view will generate a broad scene to ease navigation. The combination of real world and virtual scene will show people exactly where the object to be identified is located. The actual augmented reality systems are capable of displaying the real scene and virtual scene together simultaneously by the video merging technology using the computer graphic systems. The accurate image registration should be made ahead of video merging.

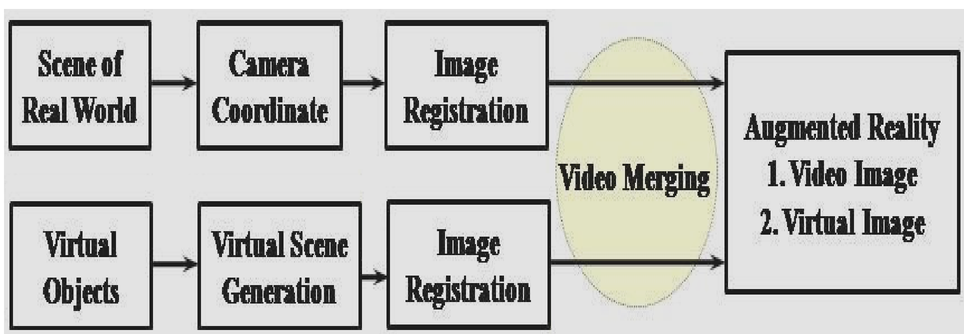

Fig. 3 Principle of Augmented Reality

5. Conclusions

This research and educational project intends to enhance the long-term educational implications of scientific and technological advances. By the integration of research and education through systemic mentoring, it contributes to the cultivating of new engineers and scientists. Training of more undergraduate students will attract potential good quality students from other disciplines and will make it feasible to apply control theories to all engineering topics. Through systematic mentoring, its contributions to the training of emerging scientists and engineers will be exemplary. The education component includes outreach activities to attract undergraduate and graduate students into engineering and science. Student participation will be recognized in the resulting publications. The institution can provide abundant opportunities where individuals will concurrently assume responsibilities as researchers, educators and students where all can engage in joint efforts that enrich education and research through the diversity of learning perspectives.

References

[1] Z. Ye, H. Majlesein, P. Bhattacharya and H. Mohamadian, "Exploring Multi-Objective Optimization to Enhance Sensor Integration Technology for Course Instruction and Laboratory Development", Proceedings of the 2006 ASEE Gulf Southwest Annual Conference, March 15-17, 2006, Baton Rouge, USA

[2] Yurkovich, S., Passino, K.M., "A laboratory course on fuzzy control", IEEE Transactions on Education, v 42, n 1, Feb. 1999, p 15-21

[3] Jurado, Francisco; Castro, Manuel; "Experiences with fuzzy logic and neural networks in a control course", IEEE Transactions on Education, v 45, n 2, May, 2002, p 161-167

[4] Hagler, M.O., Marcy, W.M., etc, "The making of the special issue on the application of information technologies to engineering and science education", IEEE Transactions on Education, Volume 39, Issue 3, Aug. 1996, Page(s):450 – 451

[5] L. Huettel, A. Brown, K. Coonley, M. Gustafson, J. Kim, G. Ybarra, L. Collins, "Fundamentals of ECE: A Rigorous, Integrated Introduction to Electrical and Computer Engineering", IEEE TRANSACTIONS ON EDUCATION, VOL. 50, NO. 3, AUGUST 2007

[6] I. Plaza, and C. Medrano, "Continuous Improvement in Electronic Engineering Education", IEEE TRANSACTIONS ON EDUCATION, VOL. 50, NO. 3, AUGUST 2007

[7] S. Mansmann and M. Scholl, "Decision Support System for Managing Educational Capacity Utilization", IEEE TRANSACTIONS ON EDUCATION, VOL. 50, NO. 2, MAY 2007

[8] Z. Ye, Control System Lab Manuals (Vol. 1, Vol. 2), Southern University, November, 2005

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