The Revision and Extension of a Computer-Based Plant Growth Imaging System

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Back ground:

The proposed collaboration between Dr. Charles Stinemetz and Dr. Robert England will result in the development of an inexpensive computer-driven plant growth monitoring system. Student exposure to this technology will illustrate the advantages of computer driven experimental approaches and enhance student understanding of plant growth and development through real-time video digitization of both two and three dimensional plant growth patterns. The initial integration of these materials into the Rhodes biology curriculum will begin through the use of this system in student research projects and in upper level biology laboratories. With additional instrumentation support this technology can easily be included in our introductory biology experience. Finally, the software and materials developed would be distributed to other ACS plant biologist and faculty with an interest in digital imagery.

Description:

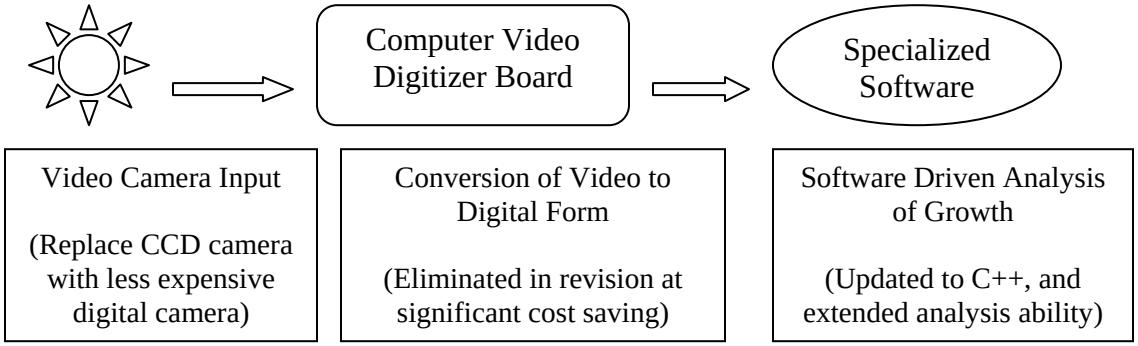
In recent years, biologists have begun to capitalize on a variety of new research tools related to the automation of data gathering, searching of large data-bases, and the creation of computer generated simulations. Thus, computer-driven instrumentation and data-base search engines are increasingly dominating modern biological studies. Although a marriage between computer technology and more traditional forms of experimentation are critical to advancing the sciences, many undergraduate students have minimal or no exposure to the use of computers as automated data-gathering equipment. Within ACS there are a variety of schools with varying levels of expertise in utilizing computer-driven laboratories in biology. In the case of Rhodes, we have successfully included a variety of computer-based experiences throughout the biology curriculum. These include the inclusion of genomic and protenomics techniques, computer-based animal physiology and neuroscience experiences, GIS-enhanced ecological studies, and computer simulations of various biological phenomena. However, few of these changes are evident in laboratory modules associated with the plant sciences. This stands in stark contrast to many of the current advances related to plant biology. By experimenting with some low cost hardware alternatives and revising existing software this project will help modernize plant biology both at Rhodes and other ACS institutions.

Previous studies have made good use of real time computer-based video growth analysis to investigate how environmental stimuli influence plant growth patterns. Much of this technology remains confined to university research laboratories in part due to the high hardware cost ($10-15K per system) and the unique nature of the associated software. These systems are driven by specialized software and rely upon video input from CCD video cameras to a video digitizer board (Illustration 1).

In this system a video image of a growing plant is repeatedly captured and the video signal relayed to a digitizer board in the computer. The board translates the video signal into a digital image. As part of this process, each digital pic cell is assigned an

intensity value. The software "views" the digital image - and through a series of calculations - can determine apical ends of the figure or recognize and track the movement of a dark or light object. This system has been successfully used to monitor a variety of plant responses including general plant growth, plant tropistic curvature, flowering opening and closing patterns, etc. Data output from this system has included the calculation of absolute and relative growth rates, determination of stimulus/response time courses, localization of growth responses, relative degree of directional growth, etc.

Illustration -1 General diagram of computer-based video growth analysis system.



To make this system more readily available to a wider variety of institutions input devices, video boards, and the software that drives the system is in great need of revision. Past video input devices were expensive (CCD Cameras), software was constructed in either basic or C+ language, and the most commonly used video board (PC Vision Plus) is obsolete. The funding of this proposal would allow Drs. Stinemetz and England to collaborate on 1) revising and improving existing software, 2) expand the capability of the software to three-dimensional monitoring of growth pattern, and 3) explore less expensive alternative video inputs (digital cameras) than the CCD cameras and video boards typically used. The revision and expansion of the software coupled with the designation of less expensive hardware components for the system, will create an attractive package for both an introductory laboratory experience at Rhodes and the export of this technology to other institutions. (Illustration-1)

Timeline:

June 1st -	Begin revising current software
	Discuss extension of software to include 3-D modeling of growth
	Review alternative input options and video boards
July 1st -	Complete revision of existing software
	Begin revision of 3-D software
	Install chosen video board and test revised software using CCD Camera
August 1st -	Complete revision of 3-D software
	Test alternative input devices with the revised system
	Prepare general description of system materials for ACS colleagues
September 1st	Mail description of system with introductory lab to plant biology and other interested ACS faculty

Technology: Most of the current expertise and hardware is readily available at Rhodes College. Most of the computer hardware and software necessary for this project is present in the Rhodes biology digital imaging center. The PIs have copies of previously used plant growth digital imaging software and have been given permission from these laboratories to use the software in this project. The two PIs for this project have unique qualifications for the completion of the project. Dr. Charles Stinemetz has more than 20 years experience in utilizing computer-based systems to monitor plant growth as evidenced through numerous publications and the successful execution of two NSF grants that introduced various imaging technology into the biology curriculum including the establishment of the biology digital imaging center. As a member of the Rhodes Math and Computer Science program, Dr. Robert England will make a significant contribution to the revision of the digital imaging software and has previously taught courses on a variety of computer science topics including digital imaging.

Other Support: Rhodes College is well positioned to support this project in terms of most of the necessary computer hardware required for the project. This project will extend the use of an already existing biology digital imaging center. Further, the college replaces computers every three years insuring that the proposed growth imaging system will be adequately maintained for many years. Follow-up funding from NSF and other external sources would be pursued for adoption of this technology into our introductory curriculum.

Learning Outcomes: The addition of this growth imaging technology into our curriculum will familiarize students with the importance of computer-based automation of laboratory techniques, introduce them to more modern approaches for studying growth and development in plant biology, and enhance their understanding of the complexity of factors involved in measuring and understanding plant growth and development. The addition of this tool will provide faculty with an opportunity to challenge students to better appreciate the regulation of plant growth and the adaptation of plants to changes in their environment.

Curriculum: The plant growth imaging system will initially be utilized by students in Dr. Stinemetz's upper level biology courses – Mechanisms in Developmental Biology and Plant Physiology. In addition, students conducting research in Dr. Stinemetz's lab will make extensive use of the system. Following student assessment of the system, we would pursue additional funding to create enough systems to employ this technology in our introductory biology curriculum.

Assessment: Both quantitative and narrative assessment tools would be employed to assess: 1) the effectiveness of the student-system interface, 2) the enhancement of particular learning goals for the laboratory modules in which the system is used, 3) student opinions of the usefulness for using computer-based laboratory data gathering equipment, and 4) determine if student engagement in learning and/or pursuing studies in the plant sciences is increased.

Collaboration and Dissemination: The results of this project will be shared both directly and indirectly with interested colleagues within and outside of the ACS. Following the completion of this project, we will prepare a packet of materials that has both a guide for constructing the digital imaging system, contains the software developed for this project, and includes two example laboratories which utilize this system. This packet would be directly mailed to other ACS plant biologist. Finally, we would disseminate these materials on a national level through presentations at meetings and through the ACS Technology Center software webpage.

Proposed Budget:

Purchase of Digital Cameras	$ 904
Faculty Salary for Summer	$1200
Fringe Benefits @33% of salary	$ 396
Total Cost	$2500