Innovation in Education Awards Application

Quantitative Image Analysis using Adobe® Photoshop® CS3 Extended

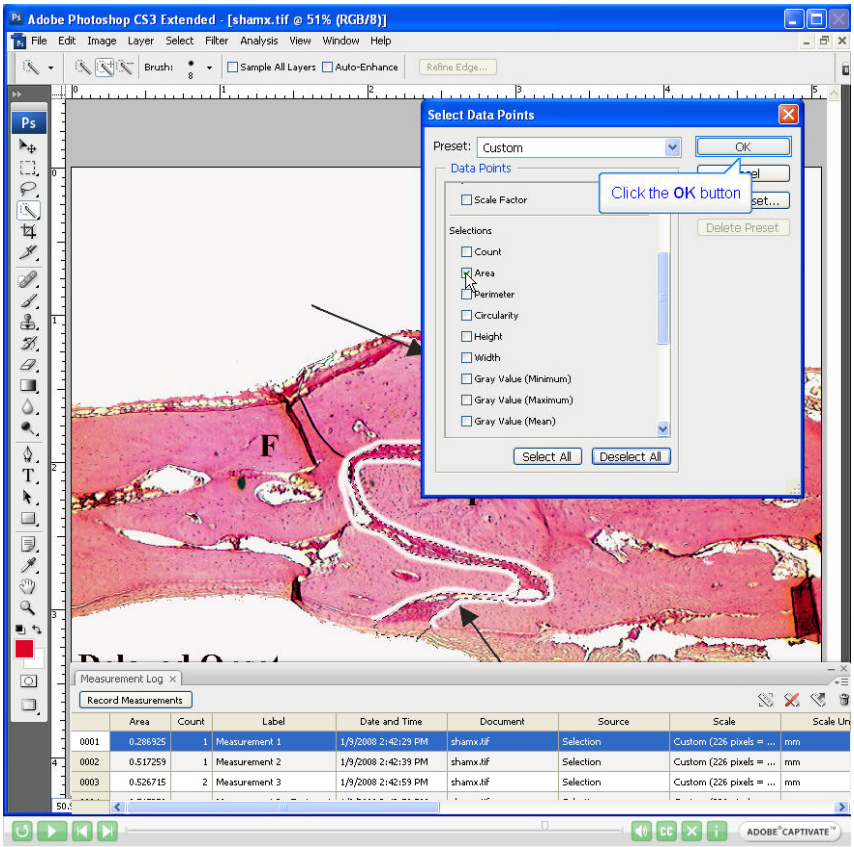

Figure 1: Browser-based video tutorial for area measurements

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Executive Summary

An increased emphasize on fostering biomedical research at the University of Pittsburgh has resulted in a dramatic increase in basic, applied and translational research activities with student involvement at all levels. A key component of many modern biomedical research methods is the production of an array of images—such as histological samples, radiological images and various other imaging artifacts derived from diverse lab equipment—all of which need to be analyzed quantitatively. Few researchers use dedicated histomorphometric software applications, yet many need an easy way to perform basic quantitative analysis. The recently released Adobe® Photoshop® CS3 Extended software (subsequently referred to as "Photoshop") offers researchers powerful tools to extract a wide array of quantitative data from images and also includes native support for DICOM images. Currently, there are no resources available to teach the skills necessary for these new software tools at Pittsburgh or elsewhere.

The goal of this proposal is to meet this need by providing undergraduate students, medical students, postgraduate students, postdoctoral associates and other research personnel with a dedicated, just-in-time teaching and best practice resource for the measurement and analysis tools of this new Photoshop. Our proposal acknowledges that this topic is not currently taught in any of the six health science schools at Pittsburgh. Further, this proposal employs the power of the newly acquired Blackboard Content System to avoid the pitfalls of traditional classroom-based lectures, which do not accommodate the scheduling needs of students working in labs.

This project proposes to develop: *Quantitative Image Analysis using Photoshop*: a CourseWeb course featuring step-by-step video tutorials as screen captures with instructor voice-over explanations covering the use of Photoshop's measurement and analysis tools. *Best Practices using Photoshop in Image Analysis*: a self-maintaining supplement will provide students with a repository of best practices for additional help and support. The supplement will be implemented using Blackboard's new wiki tool and Scholar, and will facilitate collaboration and sharing between learners.

The quality and interactivity of these two interconnected modules are key factors in the success of this learning resource, which cuts across various disciplines and caters to different learning levels. Self-assessments will allow learners to evaluate their understanding of the material in practice-like scenarios. The use of Web 2.0 technology will not only enhance the resource by employing learner contributions, but also provide the foundation for sustainability of the resource beyond the funding period.

Project director, Dr. Spallek, has a considerable understanding of the intricacies of how best to teach the complex technical procedures of Photoshop gained during the last several years when he taught his hands-on Photoshop seminars for professionals. Dr. Spallek is co-investigator for the informatics core of Pitt's Clinical and Translational Science Awards (CTSA) program (1), whose objective is to transform how clinical and translational research is conducted. His CTSA involvement has allowed him valuable insight into the training needs of biomedical research labs across the Pitt campus and will later provide access to distribution channels to the intended audience. Project co-director, Dr. Mooney, has three decades of experience with histomorphometric analysis. He is deeply involved with various research groups among the target audience, allowing him to guide the content development of this new learning resource. Carol Washburn, senior instructional designer at CIDDE, will provide guidance on the instructional soundness of the new learning resources. Eric Wexler, pharmaceutical research scientist and member of the Adobe Medical Imaging Advisory Group, will act as external consultant, offering his expertise in the image-analysis domain by covering the external testing of the videos produced. Communications specialist, Wendy O'Donnell, APR, offers the project more than 20 years experience in strategic communications planning and counsel as well as in-depth script development and writing skills.

The development of the teaching modules will proceed through a formal process of needs analysis, conceptual design, user interface design, storyboarding, prototyping, usability testing and programming. This project will provide learners with a much-needed resource for performing quantitative image analysis. All course material will be offered as Organization Content allowing free access to students across the Health Science schools.

After the funding period, the project will be maintained by Dr. Spallek, who will continue to update the resource when new Adobe product features are released. The *Best Practices using Photoshop in Image Analysis* module will consist primarily of user-submitted material and is therefore deemed self-maintaining.

The novelty associated with using PittCast-hosted video tutorials in combination with the new Blackboard-based Web 2.0 technologies, dictate that we perform an outcomes assessment based on the results of the final test of the course (a practice-like scenario for a quantitative image analysis). In addition, we plan a satisfaction survey of the various participant research labs after completion of the course.

Key Personnel

Dr. Heiko Spallek received his DMD and PhD degrees from the Humboldt University, Berlin, Germany (Charité), where he taught in the Department of Periodontology and conducted research evaluating the histomorphometric characteristics of granulated tissue of patients with juvenile periodontitis. He has worked in the field of dental informatics for more than 11 years. At Temple University, Dr. Spallek held the position of assistant professor at the Department of Dental Informatics, School of Dentistry, and received a Masters in Science and Business Administration with concentration in Computer and Information Sciences from Temple University in 2000. In 2002, he became assistant professor at the Center for Dental Informatics, School of Dental Medicine, University of Pittsburgh. He also has an appointment in the core faculty of the Department for Biomedical Informatics and an adjunct appointment at the School of Information Sciences. Dr. Spallek is an expert in the application of Internet technologies to dental education, research and practice. His current research interests include educational software; distance education; e-communities; and self-maintaining Web-based resources. He is principal investigator of an NLM-funded project developing an online community for dental informatics.

With experience bridging the fields of computer science and biomedicine, Dr. Spallek is uniquely positioned to ensure the success of this endeavor. He regularly teaches a two-day, continuing education Photoshop course “Dental Photography, Shooting Digital and How to Optimize the Result.” to practicing dentists and dental faculty. From this teaching experience, he has addressed problems encountered when teaching Photoshop techniques and adapted his courses based on participant feedback. He is member of the National Association of Photoshop Professionals and an alumnus of numerous Photoshop World conventions, the largest convention that provides tutorials by some of the best Photoshop instructors. Dr. Spallek will devote five percent of his effort to this project.

Dr. Mark P. Mooney, Ph.D. received his PhD degree in Physical Anthropology from the University of Pittsburgh in 1986. He was a Research Assistant Professor in the Department of Anthropology until he joined the Department of Anatomy and Histology in the School of Dental Medicine, University of Pittsburgh in 1991. He is currently Professor and Vice Chair of the Department of Oral Biology and Director of Student Research in the School of Dental Medicine, He also holds joint appointments in the Departments of Anthropology, Surgery-Plastic and Reconstructive Surgery, and Orthodontics. He is affiliated with the Cleft Palate-Craniofacial Center and the McGowan Institute for Regenerative Medicine (MIRM) at the University of Pittsburgh and is director of the Posvar Hall Animal Care Facility and the Surgical Anatomy Laboratory. Dr. Mooney is interested in the normal and pathological growth and development of the craniofacial skeleton. He is also interested the effects of surgery on craniofacial morphology and new techniques designed to facilitate surgical management of infants born with craniofacial anomalies. His current research activities include the development of protein and gene therapies to treat craniosynostosis and to facilitate tissue regeneration in skeletal defects in a variety of animal models. He has had extensive experience with two- and three-dimensional morphometrics from radiologic, histologic, computed and surface tomographic, MRI, PET and ultrasonographic images using a variety of quantitative software application packages such as Image J, Scion Image, Bioquant, Northern Eclipse, and Osteoplan, He has published over 300 peer-review articles, books, book chapters, and abstracts on these topics. He will work closely with Drs. Spallek and Laudato to design the user interactions of this course and lead the beta testing on real morphological samples. He will devote five percent of his effort to this project.

Goals and Rationale

The University of Pittsburgh's increased emphasize on fostering biomedical research has resulted in a dramatic increase in basic, applied and translational research activities and is reflected in a steadily growing number of research faculty, postdoctoral associates, PhD students and medical students as well as undergraduate students employed in various research labs across the campus. Many of these researchers need to quantitatively analyze two and three dimensional images from such sources as histology, traditional and laser enhanced digital images, traditional radiology, ultrasonography, computed and surface tomography, positron emitted tomography and magnetic resonance imaging. While there are dedicated histomorphometric software applications available (Image J and Scion Image from NIH or Bioquant, Northern Eclipse and Osteoplan from private vendors), researchers face many barriers to their use. These barriers stem from feature overload of the applications resulting in a steep learning curve, from high price or from the complexity of the initial setup. This circumstance is exacerbated by the fact that many of these applications are geared solely towards histomorphometric analysis and thus not suitable for other quantitative image analysis, such as two and three dimensional analysis of plane film radiographic, CT, MRI, PET, ultrasound, and laser enhanced surface images. Only the few researchers who focus on histomorphometric analysis can justify such an investment in time and/or effort. The rest, who make up the majority and for whom quantitative image analysis is just one among many methods used, are involved in short-term training research projects and cannot afford the time to train their research assistants in the use of a complex application or to pay a high price for an application. These researchers need an off-the-shelf, easy-to-use software package that is useable by all lab members. The recently released Adobe® Photoshop® CS3 Extended software application (subsequently referred to as "Photoshop") offers powerful tools for rapid extraction and export of a wide array of quantitative data from digital images.

The opportunity to use a mainstream software application for quantitative image analysis is important alternative but rapidly loses appeal because no training is offered at Pitt or elsewhere to teach the skills necessary for proficiency (see Appendix C: external support letters). No dedicated books are available, no best practice examples can be found and no online tutorials are available which go beyond the very basics. The goal of this proposal is to meet this need by providing an online, just-in-time teaching and best practice resource for Photoshop's measurements and analysis tools (see Appendix B: internal support letters) accessible campus-wide. While one-on-one interactions with an instructor are the gold standard in education (2), from an instructional design perspective it is difficult to teach image analysis skills in a traditional classroom setting. To accommodate lab personnel scheduling needs and turnover issues as well as the diverse range of potential Photoshop learners—from undergraduate students enrolled in the First Research Experience program (Office of Experiential Learning) to full-time PhD students and faculty researchers—the course will be offered as part of the Blackboard v.7.3 Organization Catalog and be freely accessible to all students on the Health Science Campus. The Organization Catalog is part of the newly acquired Content System that enables learning for a role-based community of students outside the traditional course structure. (This and all other Blackboard-based features mentioned in this proposal were previously discussed in detail with Nick Laudato on December 20th, 2007.) Once the course is launch-ready, we will contact the University's Center for Continuing Education in the Health Sciences (3) requesting certification of the new learning resource for CME credits.

Project Description

The CourseWeb online Photoshop course will consist of two interconnected and interdependent just-in-time learning modules for the quantitative analysis of digital images using innovative instructional approaches ranging from video tutorials of screen captures to community-based Web 2.0 approaches. When used in conjunction, they are intended to prepare learners for conducting independent quantitative image analysis tasks in a wide variety of research settings.

Quantitative Image Analysis using Photoshop – The video component of the online course will equip research personnel with a set of foundational skills in quantitative image analysis using Photoshop. The course uses both in-depth step-by-step tutorials as well as screen-captured video tutorials with instructor voice-over explanations. Topics include how to bring pictures from diverse electronic and non-electronic sources into Photoshop, how to make selections based on various criteria and how to use Photoshop's measurement tools creatively. At the end of each section, self-assessments let learners evaluate their grasp of the material in a "practice-like" scenario. Self assessments include multiple-choice questions, fill-in-the-blank questions, matching exercises and tasks. A download section will provide all practice example files in various stages of completion. The video will be placed on CIDDE's new PittCast (4) delivery system, a service that allows Podcast additions to courses so learners can subscribe to the podcast (RSS will be created as well) using applications such as Yahoo! Music, iTunes, iPodder or FeedReader. Dr. Mooney's expertise in histomorphometric analysis will be used to teach image analysis aspects, such as system validity (i.e., is it measuring what it says it is) determination of inter- and intra-rater reliability of measurements (i.e., reproducibility).

Best Practices using Photoshop in Image Analysis – This supplemental module will evolve into a comprehensive repository of best practices and case examples, and become the nucleus of a user community that offers help and support to new researchers thereby guaranteeing the sustainability of the project. This resource will be implemented using Web 2.0 technology-based tools that are part of Blackboard. The term Web 2.0 is a perceived second generation of web-based communities and hosted services that facilitate collaboration and sharing between users. We will use Blackboard's wiki tool to implement a "live" help and support system. This in keeping with the software application support trend away from dedicated support staff (help desk) toward a community-based moderated user forum. In the spirit of these community-based applications, this supplemental module will act as a substitute for traditional interactions between instructor and students. Tapscott and Williams argue in their book Wikinomics (5) that there are four key characteristics associated with successful collaborative projects: openness, peering, sharing, and acting globally. We will exploit the power of the Web 2.0 technology for teaching by offering the *Best Practices using Photoshop in Image Analysis* module in Blackboard v.7.3 Organization Catalog so it is freely accessible to everybody on the Health Science Campus. It will further support peering by tapping into the diverse pool of learners via Blackboard's wiki tool. Social bookmarking is a way for Internet users to store, organize, share and search bookmarks of Web pages. Most social bookmarking services encourage users to organize their bookmarks with informal tags instead of the traditional browser-based system of folders. The *Best Practices using Photoshop in Image Analysis* will include a resource guide providing links to related resources and tutorials, such as Adobe's Medical Professionals Website (6). This resource guide will be built by the learners using social bookmarking and implemented by Blackboard's new Scholar (7) system. This process will result in a single resource list of relevant bookmarks collected by

faculty and students.

Figure 1 is a screen snapshot of a video tutorial on how to measure a selected area using a custom measurement scale. The video was captured using Adobe Captivate 3 screen recorder with voice-over from the instructor. This teaching technique has been used successfully for Photoshop in the past (8). Dr. Spallek uses the same technique for his continuing education course (9). His unique combination of teaching experience and academic work, which bridges computer science and biomedicine, enable him to overcome the many challenges of a learning module that cuts across disciplines and includes different learner levels. (See Dr. Spallek's resume for further details.)

Our application for funds is to develop and implement two innovative modules and self-assessments for Photoshop. The delivery modes for two modules are:

Video tutorials: Since complex procedures are better shown continuously than via static textual descriptions, a screen-capture video tutorial with instructor voice-over is the optimal vehicle for this how-to tutorial.

Self Assessments: Learners will evaluate their understanding of the material in small self-assessment quizzes at the end of each section.

Final Test: Learners will be tested for their ability to perform a quantitative image analysis at the end of the course in a practice scenario. The combined results of this test will be used as one of the outcome measures.

Download section: A download will provide all practice example files in various stages of completion.

Wiki Tool: This tool will substitute for interactions between instructor and students, provide access to best-practice examples, act as a help and support center and also build the nucleus for a thriving learner community.

Social bookmarking: This will help build a resource guide that lets users assign keywords to resources fitting the framework of quantitative image analysis via Blackboard's Scholar service.

Project Plan

We will conduct a needs assessment survey among research labs of the health science schools to determine the focus of the learning resource and also to provide guidance on applicable examples (general support and interest was already demonstrated: see Appendices B and C). Development of the teaching modules will proceed through a formal process of: conceptual design, user interface design, storyboarding, prototyping, usability testing, and final programming. Initial development of the *Quantitative Image Analysis using Photoshop* module will begin by creating the storyboard which will specify the instructional approach as well as content and sequencing. Conceptual design will be performed by the project personnel including CIDDE's senior instructional designer, Carol Washburn. Eric Wexler, our external consultant and a renowned expert on image analysis, will undertake a content review. Video script development and oversight will be undertaken by Wendy O'Donnell to ensure consistency and accuracy of content as well as suitability of language, theme and tone. This will be followed by screen captures for the video tutorials and instructor voice-overs. The module will be completed by designing the CourseWeb course. The CourseWeb environment provides navigational support, allowing learners to complete self-assessment tests at the end of each section as well as administering a final test. Both video tutorials and self-assessments will undergo several rounds of formative evaluation using the think-aloud protocol with users and heuristic evaluation by experts. Formative evaluation will begin

in the design phase, where we plan to test several different storyboards with dental, medical, and graduate students, residents and postdoctoral fellows, and junior faculty members associated with Dr. Mooney's lab. A second round of formative evaluation will occur with the completed video tutorials and self-assessments prior to their release. Melanie Leung, a research assistant in the Center for Dental Informatics, will assist in designing and conducting the usability tests and also act as research assistant throughout the entire project phase.

The CourseWeb environment facilitates the interplay with the second module, *Best Practices using Photoshop in Image Analysis*. Parallel to the development of the first module, we will use Blackboard's new modules to build the electronic infrastructure for the planned e-community.

Impact on Teaching

There is no product on the market to teach Photoshop for quantitative image analysis yet there is a significant need among the Pitt biomedical researcher community for such a product (see Appendix B: internal letters of support). The potential student base for this Photoshop teaching tool is vast: students are employed in labs on all levels and start as early as their undergraduate years through programs such as the First Research Experience administered by the Office of Experiential Learning. Access to a Photoshop CourseWeb course, consisting of two complementary modules, *Quantitative Image Analysis using Photoshop* and *Best Practices using Photoshop in Image Analysis*, will have a significant impact on teaching. The ad-hoc, one-on-one instructional approach of time-pressured researchers will be superseded by a well-designed online teaching resource that cuts across disciplines. Students with this formal training in quantitative image analysis methods will bolster their resume and improve their chance of gaining a research position after graduation.

Marketing to all biomedical research labs at Pitt will begin once course development is complete. The course will be offered in Blackboard's Organization Catalog that is shared across the Health Science Campus making it accessible to all students and faculty. Additionally, it can be integrated in whole or part into other courses. Dr. Spallek's involvement in Pitt's CTSA (1) will ensure appropriate positioning of the new resource and distribution about its benefits through various electronic and traditional channels.

We expect the teaching impacts to extend beyond the Pitt Health Science research community, with awareness and diffusion coming from local presentations (such as the Teaching Excellence Fair) and papers/presentations at national venues. We intend to present our results at the next New Media Consortium (NMC) meeting (10) (University of Pittsburgh is member of the NMC). And we anticipate the project acting as a catalyst for greater adoption of Web 2.0 technology modules inside Backboard. The ultimate expectation is that the use of video tutorials for hands-on research methods will release researchers from repetitively teaching basic methodological skills; their time will then be spent on more productive, higher-order tasks.

Sustainability of the Project

The modules require minimal maintenance once initial development of *Quantitative Image Analysis using Photoshop* and *Best Practices using Photoshop in Image Analysis* is completed. Dr. Spallek will performed necessary updates when Photoshop releases new versions. The key element of sustainability is the resource's use of community-based tools featured in *Best Practices using Photoshop in Image Analysis*.

The CourseWeb course will be implemented as part of the Blackboard Course Management System and therefore maintained by CIDDE/CSSD. Thus, no operational expenses are required for the modules. Using Pitt's CTSA, communication efforts will be continuous and ongoing to keep awareness high.

Outcomes Evaluation

Evaluating educational software is a difficult undertaking (11,12). Formative evaluation during the project development will ensure usability and usefulness for the intended audience. However, a summative evaluation is more difficult. For instance, comparative media studies in which a computer-based program is compared to a traditional lecture suffer from several methodological flaws (11). Richard Clarke (13,14) argues that most effects are due to better instructional design not due to the media used. Since a computer may provide inherently better instructional value (e.g. showing computer operations that cannot be shown otherwise) then comparing it to a traditional model is inherently biased.

In addition to methodological problems when evaluating educational software in comparative experiments, this particular project would face several logistical problems if such an approach were used. First and foremost, no equivalent lecture course exists. Second, the just-in-time nature of the learning resource makes evaluation even more difficult.

To avoid these obstacles, we propose to perform a formal, summative evaluation based on the results of learners' completed final tests, which measure ability to perform a quantitative image analysis in a practice-like scenario. We will evaluate the records of the self-evaluation testing, monitor community size and its growth rate, characterize participants and their affiliations as well as usage and activity. In addition, we plan a survey among various research labs one year after completion of the course. Informal feedback will be solicited on the learning resource Website and evaluated periodically. The results will be presented at the Teaching Excellence Fair as well as submitted to the next NMC meeting.

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