Dynamic Homework Annotation

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Abstract

We present the first case study involving the use of dynamic homework annotation, *where an instructor uses a pen input device and a microphone to record audio comments while marking up an electronic copy of a student's homework assignment. The student can then view the resulting animation using any web browser, for an experience similar to that of sitting beside an instructor who personally explains the strong and weak points of the student's work. As one might imagine, dynamic homework annotation requires more time and technical expertise on the part of the instructor, but holds the promise of giving much more useful feedback to students. In this paper, we discuss our assessment of both of these issues resulting from use of dynamic homework annotation in a semester-long graduate data structures course at Clemson University.*

1. Introduction

One of the primary uses of tablet PCs to date is that of annotating electronic documents. Several programs (e.g., Microsoft Journal) allow the user to add ink annotations on top of virtually any electronic document with ease, allowing for many exciting educational applications. For example, an instructor may use a tablet PC to annotate slides or lecture notes in class, then make the resulting annotated documents available to students on the web. Alternatively, one can use pen computing to achieve a completely paperless means of annotating and returning students' homework assignments [2, 3, 4]. It is this particular application — homework annotation — that is the focus of this paper.

Aside from the logistical benefits of going paperless, static electronic homework annotation unfortunately offers no extra educational benefit per se compared to traditional grading using pen and paper. By freeing ourselves from the constraints of traditional pen and paper grading, however, there are many opportunities to enhance the learning experience. This paper presents a case study of the author's use of *dynamic homework annotation*, where an instructor records an audio commentary while making dynamic ink annotations on students' homework assignments. The resulting animations can be viewed using any web browser, for an experience similar to that of sitting beside an instructor who personally explains the strong and weak points of a student's work.

As one might imagine, dynamic homework annotation holds the promise of delivering far more effective personalized feedback to students in order to enhance their understanding of course material. The ability to create dynamic illustrations and speak allows an instructor much greater flexibility in articulating difficult concepts in a manner that is easy for students to follow. This added flexibility can be a great benefit in several types of classes, ranging from mathematics, science, and engineering, to the humanities. To give a simple example, a music instructor may wish to take students' scores (submitted electronically) and add dynamic ink annotations along with audio that includes verbal explanations as well as the instructor playing examples on an electronic keyboard.

Although it offers significant education potential, dynamic homework annotation also requires more time and technical expertise on the part of the instructor. Does this extra work justify the added educational benefit? In this paper, we provide some guidance towards resolving this question by discussing our assessment of both instructor time requirements and educational benefit to students based on the use of dynamic homework annotation in a semester-long graduate data structures course at Clemson University.

The structure of this paper is as follows. We begin by describing the setting and framework used to create dynamic homework annotations. We then present a detailed assessment of their educational effectiveness and the amount of extra work required of an instructor to create them, followed by conclusions and suggestions for future work.

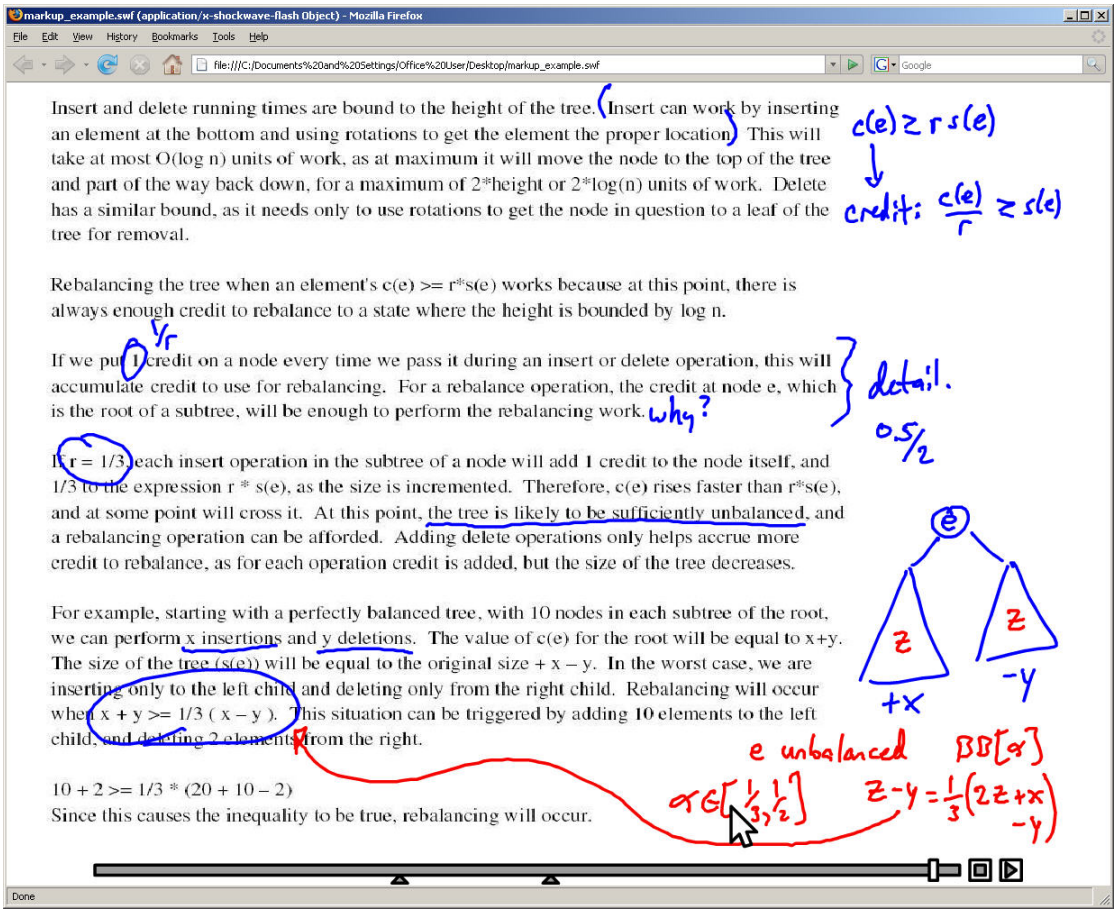

Figure 1. An example of a dynamic homework annotation video playing back in a web browser. A status bar at the bottom allows the user to control playback by pausing the animation or by jumping to a particular frame. Also note the use of arrow to gesture at previously-drawn content.

2. Methods

Sixteen students participated in CpSc838, a graduate data structures course taught by the author, in the fall term of 2006. Students were instructed to submit homework electronically in any convenient format (preferably as PDF files). The author then used a program called LectureScribe (discussed shortly) to record audio and dynamic ink annotation over each homework submission, the result of which was exported to a highly-compressed Macromedia Flash file and uploaded to a campus web server. In class, each student was then handed a small piece of paper containing the web address to visit in order to view the feedback on their assignment. Figure 1 shows an example of one of these animations playing back in a web browser.

Over the course of the semester, students submitted a total of 385 pages of solutions to 7 homework assignments, and received in return 17 hours, 18 minutes, and 29 seconds worth of animated feedback. In addition to this, the author posted a total of 4 hours worth of animations containing general solutions (non-individualized) to each assignment. At the end of the class, students were given an anonymous survey asking for their perceptions as to the effectiveness of this new form of homework feedback.

2.1. Software Tools

Virtually any screen capture program or presentation annotation program that records audio (e.g., Camtasia, Adobe Breeze, or Speechi) can be used to create dynamic homework annotation videos. For this study, the author used a program of his own creation, LectureScribe[1], that was specifically designed to simplify and streamline the task of creating short animations comprised of audio and dynamic

[1]LectureScribe is freely available. For further information, please see `http://www.cs.clemson.edu/~bcdean/lscribe/`

ink [1]. Material can be imported into LectureScribe as a series of images or alternatively simply by "printing" a document into LectureScribe. Once a document has been imported into LectureScribe, the user simply clicks a button or presses 'R' to start recording, then speaks while adding ink annotations with a pen input device. For this study, the author used a Wacom Cintiq tablet monitor, although a tablet PC, an electronic whiteboard, or an inexpensive USB drawing tablet would also suffice. Using simple keyboard shortcuts, one can in real time switch drawing modes between ink and a pointer for gesturing at previously-drawn content, or one can stop, back up, and reset the recording in the rather common situation where one misspeaks (these streamlined controls for common tasks are one of the main benefits of using LectureScribe over other programs, where it can be quite cumbersome to, say, reset the recording after misspeaking).

A video produced with LectureScribe can be exported to a single Macromedia Flash (SWF) file, which can then be emailed to a student or embedded in a web page or PDF document. Due to the ubiquity of the Flash format, these files can be viewed in essentially any modern browser without the need to download any additional plugin, and the vector nature of the format allows them to stream over even a low-bandwidth connection (a typical rate is roughly 5 kilobytes per second). No special server software is required to publish or view the files created with LectureScribe.

3. Assessment

In this section we measure the advantages (for the students) versus the disadvantages (for the instructor) of using dynamic homework annotation.

3.1. Instructor Time Required

In total, the 21.31 hours of content produced as part of this study took the author a total of 30.5 hours to produce using LectureScribe, although this also includes the time spent reading students' work and pondering whether certain troublesome solutions were in fact correct, and how to best annotate those that were not. For a new instructor not yet familiar with LectureScribe (or any other screen capture software of choice), the time penalty for creating such animations is likely to be slightly higher at first than the factor of roughly 50% experienced here. Traditional pen-and-paper grading is likely to require significantly less time, with the exact amount depending highly on the course and the particular instructor. Other factors that influence the convenience and overall time required to produce dynamic homework animations include the need for a quiet environment where constant speaking into a microphone will not bother one's neighbors, and the possible need to break up long recording sessions to avoid losing one's voice (a side effect of speaking into a microphone for several hours that the author had not anticipated).

One somewhat unexpected issue the author noticed that contributed extra time to the preparation of homework videos was the difficulty in sometimes choosing the most "diplomatic" way to phrase one's verbal feedback. For example, if a student completely misses a problem, then using pen-and-paper grading one typically feels no remorse writing a large red 'X' and moving on, but when preparing animated feedback it somehow feels less satisfactory to give such a blunt response; instead it often feels more appropriate to say a few positive words of encouragement — perhaps pointing out how part of the solution seems to be heading in the right direction. Similarly, if a solution is entirely correct, instead of just drawing a check mark and moving on, one often feels compelled to say a few more insightful remarks, such as which parts of the solution are particularly well-worded versus parts that could possibly use further polishing.

3.2. Educational Effectiveness

In general, students' response to dynamic homework annotation was extremely positive. Many remarked that it was a much more "fun" way to receive homework feedback, which as a positive side effect caused the students to devote more time, energy, and focus toward understanding the feedback they received. One student wrote "I think that dynamic homework annotation could be useful ... even if the instructor only used audio and occasionally underlined or marked sections of the assignment. I think that comments in audio, whether positive or negative, will have a greater impact on the student rather than if they were just written down".

Figure 2 summarizes the result of an anonymous student survey taken at the end of the semester. As one can see, the students unanimously agree that dynamic homework annotation is significantly more effective than traditional static homework annotation. Of course, this is measuring the students perception of their learning improvement rather than their true ability (as would be evidenced by, say, grades and test scores), but previous studies (e.g., [5]) have shown that the two tend to be highly correlated.

Perhaps the most notable response from the survey is from question 2, where 11 of 13 students strongly agreed that dynamic homework annotation helps them understand their mistakes better than static homework annotation. In fact, many students wrote that not only was it easier to understand their blatant mistakes, but also they could more easily identify parts of their work that had minor or subtle flaws versus parts that were highly correct (whereas traditional static grading often focuses more prominently on ma-

		SA	A	N	D	SD
1.	In general, I think DHA is more effective at helping me learn than SHA.	5	8			
2.	DHA helps me understand my mistakes better than SHA.	11	2			
3.	With DHA, I find myself paying closer attention to the instructor's feedback than with SHA.	9	4			
4.	With DHA, I find myself spending more time reviewing graded homework than with SHA.	5	6	1	1	
5.	It is definitely worthwhile to spend any extra time required to review DHA feedback (beyond the time typically required to review SHA feedback).	6	7			
6.	I believe DHA would be an effective grading mechanism in other courses.	3	8	2		
7.	Even if animated general solutions are made available, there is still significant added benefit to providing dynamic feedback on an individual basis.	7	5		1	
8.	DHA is probably only necessary for a small fraction of the feedback on my homework assignments; for the rest, SHA should be sufficient.	2	5	3	2	1
9.	The extra work of finding a computer and browsing to a web page makes it less likely for me to view DHA feedback than SHA feedback.		1		5	7
10.	DHA is more "fun" than SHA.	7	3	3		

Figure 2. Assessment of the effectiveness of dynamic homework annotation (DHA) compared to static homework annotation (SHA). Students were asked to complete an anonymous survey indicating whether they strongly agree (SA), agree (A), had a neutral opinion (N), disagree (D), or strongly disagree (SD) with the statements above. A total of 13 of 16 students participated in the survey.

jor mistakes). One student wrote that "Dynamic homework annotation allows a professor to elaborate, and most importantly, make clear what is correct as well as what is wrong. The positive feedback from dynamic homework annotation gave me confidence to work on the areas in which I was weak".

It is worth noting from question 7 that most students considered *individual* animated feedback to be quite valuable even in the presence of fully-animated general solutions. However, as one student admitted, "I occasionally just skipped through an animation just to see my score since I already knew why and how my submitted solution was incorrect from the master solution key". Based on similar comments from other students, and in the interest of saving as much time as possible during grading, it seems most effective to refer to the general solutions and avoid reproducing the full solution to a problem in a student's individual feedback if his or her solution is completely wrong. Rather, it seems more worthwhile to focus on correcting subtle or non-standard flaws in the individual feedback. Consequently, dynamic homework annotation seems most effective when used in conjunction with homework problems having some depth, on which students are likely to make a variety of subtle errors. When asked about the classes for which dynamic homework annotation would be most effective, one student summed up this idea quite will by saying "Classes that can have many solutions for problems would probably be best. If there is only one way to do something or one specific answer for a question, it doesn't seem there would be much value. Also, it seems like classes where the process is more important than a final result would benefit more".

The only negative point consistently mentioned by students was that animations are somewhat difficult to review quickly, for example when preparing for a test later in the semester. Many students suggested offering general homework solutions in animated form as well as in a traditional written document.

4. Conclusions and Future Challenges

Based on students' comments and the observations of the author, it is hard to dispute the fact that dynamic homework annotation enables a more effective means of providing feedback to students, and that it carries significant potential for improving the learning process. However, these potential benefits must be carefully weighed against the extra burden placed upon the instructor in order to decide on the best course of action to pursue in any given class.

It is also not yet clear exactly which types of courses are best suited for dynamic homework annotation, and it would be interesting to extend this study in the future to additional types of class from both the sciences and humanities. One might also wish to investigate class scenarios involving two-way dynamic interaction between the instructor and student; for example, a student learning Japanese might submit an animated homework assignment illustrating the process of drawing Kanji characters, and an instructor could then add

dynamic annotations and audio on top of this in response.

As a result of this case study, the author is of the opinion that a mixture of static and dynamic homework annotation may be the best approach in many cases. If a student answers a problem entirely correctly or missed it completely, then static annotation typically suffices (particularly if a set of general solutions is available in animated form). However, in the (much less common) situation where the student makes a subtle error, fully dynamic homework annotation is extremely useful for allowing the instructor extra flexibility in articulating the exact nature of the error. Hybrid static/dynamic annotation would therefore provide the most useful feedback to students while still minimizing the time required for grading on the part of the instructor. It remains a challenging open question to determine the most intuitive framework (both for the student and instructor) for providing hybrid static/dynamic homework annotation.

References

[1] B. C. Dean. Beyond screen capture: Creating effective multimedia whiteboard lectures on a tablet PC. In *Proceedings of the 1st Annual Workshop on the Impact of Pen Technology in Education (WIPTE)*, 2006.

[2] M. A. Perez-Quinones and S. Turner. Using a tablet-PC to provide peer-review comments. Technical Report TR-04-17, Virginia Tech Department of Computer Science, 2004.

[3] J. L. Popyack and N. Herrmann. Electronic grading: When the tablet is mightier than the pen. *Syllabus*, pages 18–20, Jan 2003.

[4] R. Simha, S. Hanlon, M. Gaiman, J. Kiraly, and E. Arai. Blaise: Free, open-source software provides paperless support for writing courses. *TECHNOS*, 3, 2006.

[5] S. Walker and B. Fraser. Development and validation of an instrument for assessing distance education learning environments in higher education. *Learning Environments Research*, 8:289–308, 2005.