Streamliner: A General-Purpose Interactive Course-Visualization Tool

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Abstract

We present StreamLiner, originally developed as an interactive 'focus+context' tool for visualizing biologists' laboratory notebooks and other time-based activities, both on-line and off-line. We describe how to adapt StreamLiner as a teaching tool for biology students: Streamliner provides a unified way to visualize any type of stream, including the course calendar (lectures, labs, homework, exams), external events (seminars, meetings, office hours) and work produced by the course participants (student assignments, professors' comments, blogs, wikis and group projects). We used course data from two four-month degree programs that taught biology students about computer programming. Three professors identified how key features of StreamLiner would help both students and professors and suggested additional ideas for improvement. We argue that the StreamLiner approach offers a new way of managing diverse course data and can act as a general-purpose, interactive, course-visualization tool.

1. Introduction

Like many fields, computer technology has radically changed the practice of biology and how it is taught. Organizations such as the Institut Pasteur provide diploma courses to teach programming to novice through senior biologists. So students, in addition to learning traditional working patterns in limited time, are now also required to master a variety of online tools. This is especially difficult because these tools are evolving rapidly and students must learn to adapt. Laboratory notebooks are an essential way for biologists to record their ideas and results. These may be traditional paper notebooks or on-line, ranging from informal blogs to sophisticated electronic notebooks.

Unfortunately, most laboratory notebooks are designed primarily to help *capture* information: ideas, methods and results. We are interested in providing tools that also help to *visualize* and *interact* with information. This is important for students, to help them identify their own work patterns, to make sure they have not forgotten a step or to help them find a critical piece of information. This is also important for professors, to give them an overview of each student's progress and to provide relevant feedback at appropriate times. We are also interested in the more general problem of helping students and professors to keep track of and share each others' work, in any course context.

This paper begins with a summary of related work and then presents StreamLiner, a tool for visualizing and interacting with activity streams, including entries to laboratory notebooks, email and web visits. We then describe our interviews with professors about how to use StreamLiner explicitly as a teaching tool. We analyze StreamLiner's potential for visualizing and interacting with streams of events and activities, for any course, and conclude with directions for future research.

2. Related Work

Instructional strategies, such as Problem-Based Learning (PBL)[1], engage students in collaborative solutions to complex real-world problems and encourage reflection about their experiences. Merrill[9] argues that professors should begin with worked examples, then introduce simplified versions of real-world problems and finally extend the problems to make them more realistic. Many science professors, in their everyday teaching, require that students keep a laboratory notebook, either paper-based or electronic, as a tool for recording their ideas and results [6]. They use these notebooks to track students' progress and to identify any problems [3].

In addition to traditional paper-based laboratory notebooks, researchers have also experimented with a variety of electronic notebooks. Some, like A-book [8] and Butterfly Net [15], 'augment' the paper notebooks, capturing hand-written text and linking it to various functions on the computer. Others, like SmartTea[12] or MyTea[13], try to retain the affordances of paper while also benefiting from the computer. Still others are entirely electronic and range from very simple blogs and wikis to sophisticated electronic notebooks [5].

Laboratory notebooks are designed to capture detailed information about an experiment or research project, over

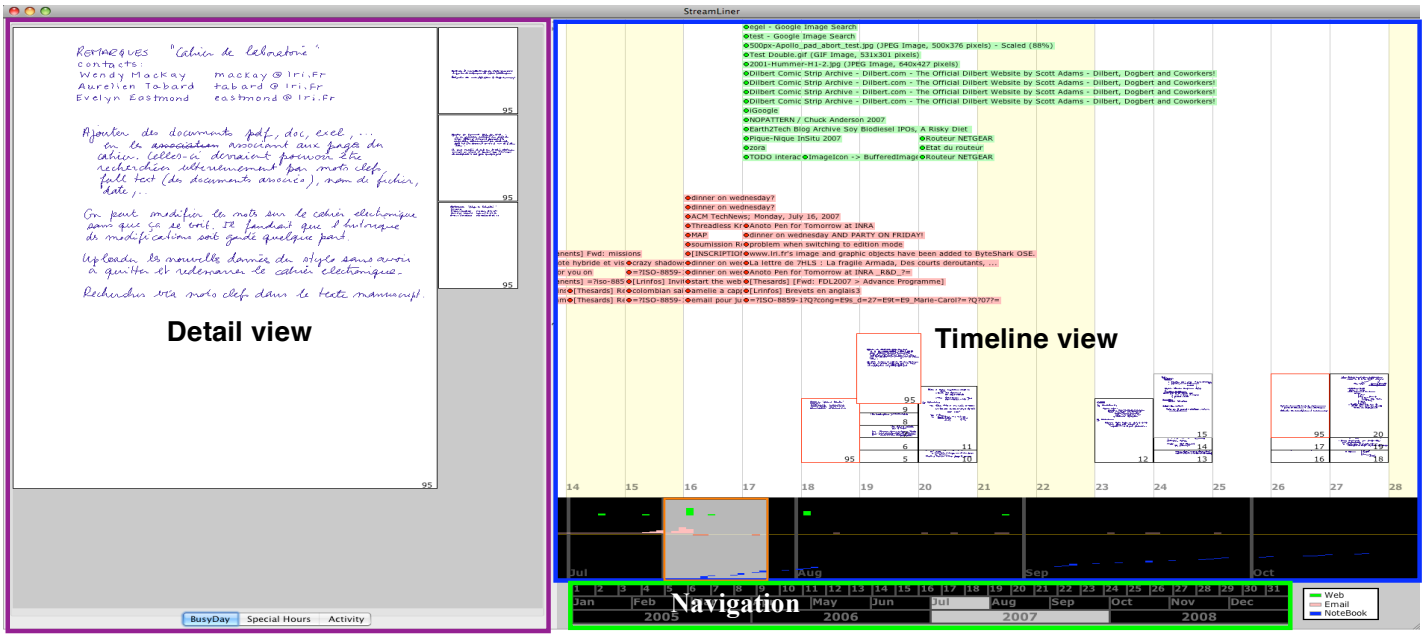

Figure 1. Streamliner: a. Detail View (left) b. Timeline View (top right) c. Navigation panel(bottom right)

time. This chronological organization is very useful for *capturing* information in a disciplined way, but does not provide a good *overview* of the work, either for the individual student or for the professor, who cannot step back and look at the general structure of the notebook.

Timelines provide an intuitive approach for representing streams of temporal data and can be used to visualize and evaluate patterns and progress. Cousin and Kahn [2] introduced a formal mathematical definition and define *events* as the only displayable element on a timeline. *Interactive Timeline Editing and Review* [7] is a framework for creating and viewing generalized timelines, with the interactive display of both metadata and events. In this case, the metadata must be restructured manually and stored in a data file before presentation. Lifelines[11] provides a comprehensive visualization environment for personal histories, using timelines that provide direct access to the data. However, the timeline presentation is not intuitive and does not provide a combined '*focus + context'* view [4]. In contrast, the Simile timeline[1], a Web2.0 widget, provides an easy-to-understand pattern for visualizing time-based events. Simile provides two inter-related views: the detailed *focus* view at the bottom and the *context* or overview at the top. StreamLiner is implemented with Simile-style patterns.

3. StreamLiner design

We initially developed StreamLiner as an interactive tool to visualize temporal data from Prism [14], a hybrid paper-electronic laboratory notebook. Prism captures hand-written gestures on paper using Anoto technology[2], which uses a tiny camera in a pen that reads an invisible dot pattern on paper. Prism also captures a variety of on-line streams of activity, including email, web visits and electronic documents. Our goal was to help biologists to understand their own work practices and that we, as researchers, could better understand how professional biologists use electronic media in their work.

Streamliner is implemented using a timeline technique coupled with carefully designed interactive attributes. This design provides (a) an intuitive presentation of both paper-based and electronic data; (b) multi-scale visualization; and (c) a simple and efficient navigation mechanism to find precise dates.

4.1 Focus + Context Visualization

StreamLiner uses a Simile-pattern visualization, with two main panels: Detail view and Timeline view (fig. 1). The panels are inter-related and display the same dataset on different scales. Dragging the background of either panel scrolls the other accordingly. The X-axis of both panels represents and maintains the whole time span of the dataset; the Y-axis is used to stack concurrent events.

The data consist of tagged email messages, weblinks and replicas of pages from a paper laboratory notebook, captured with Anoto technology,. Streamliner lets users visit all the data at various levels of detail without losing context. Users can look at the Timeline panel to see the quantity of marked emails and weblinks, as well as successive pages of the lab notebook. The Detail view shows a series of thumbnail images with email subject headers, web titles and tiny replicas of the paper pages. Clicking on a specific event in the TimeLine view displays a full-size image of the email, web or paper page, including any revisions. The latter allows biologists to review how they have modified their pages over time.

[1] *http://simile.mit.edu/timeline/*
[2] *http://anoto.com*

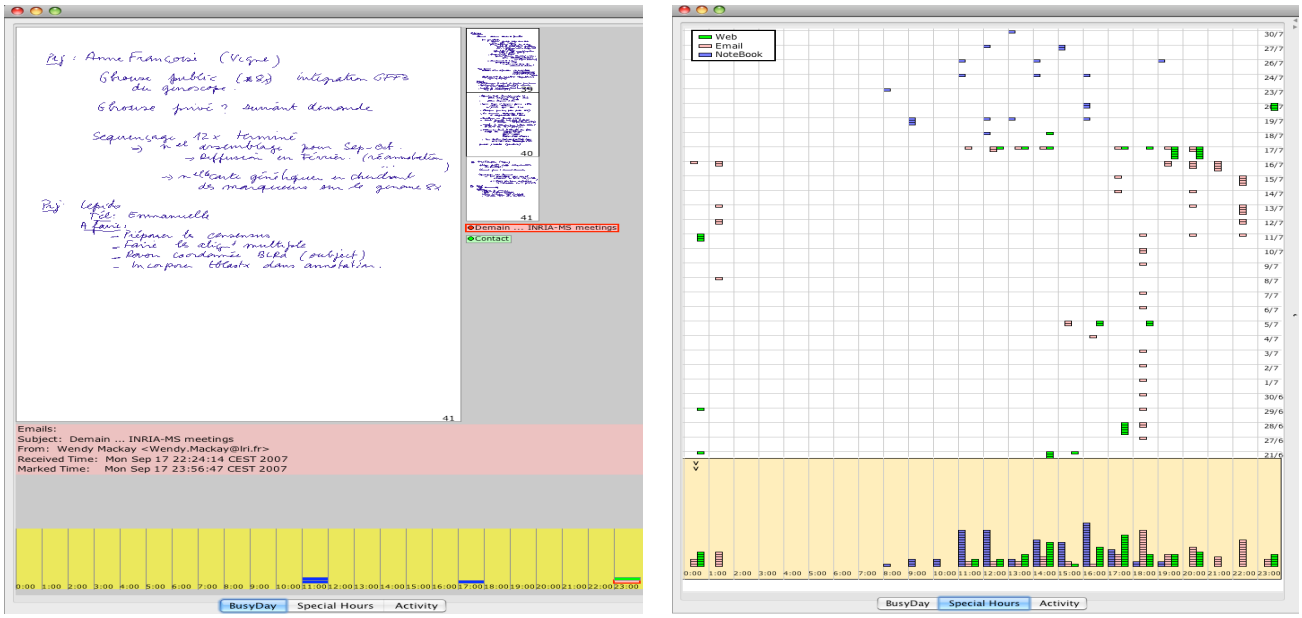

Figure 2 a. Biologist's perspective shows detail, b. HCI researcher's view shows quantitative summary(right)

4.2 Multi-Scale Visualization

StreamLiner was designed for two audiences: the biologists who use the Prism hybrid laboratory notebook and Human-Computer Interaction (HCI) researchers, who study how they work. Fig. 2 shows two different views of the same information, from each users' perspective. Biologists can check the details of a particular page and the related email or web events that occurred at the same time (fig. 2a). On the right, HCI researchers get a quantitative view of each of the different types of events, which reveals different aspects of the biologists' work patterns (fig 2b). For example, is there a regular pattern for "writing up" results in the paper notebook and how does that relate to the biologist's work on the computer?

4.3 Navigation

StreamLiner provides an intuitive method for navigating through time. To select a particular day, such as September 17, 2007, the user slides the mouse in the Timeline view, first to 2007, then to September and finally to day 17. The relevant year, month and day are highlighted in grey (bottom right, fig. 3) and the details, including a full-sized image of the page from the paper notebook, the headers from tagged email and the URL for tagged web pages, appear in the Detail view (left panel, fig. 3). To make it easier to view the days before and after, tiny thumbnail images of the relevant pages, plus the relevant emails and websites, appear to the right, in the left panel.

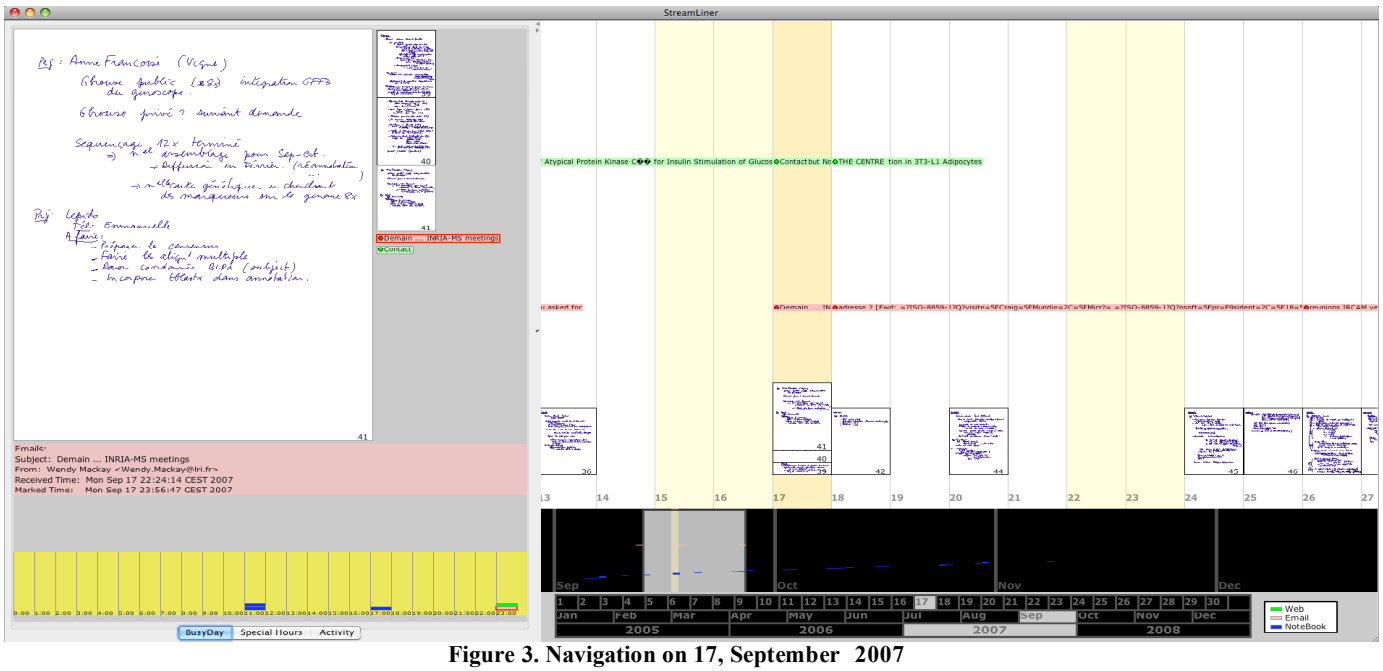

Figure 3. Navigation on 17, September 2007

5. Feedback: How to Adapt StreamLiner

We were interested in additional applications of StreamLiner. Based on our experiences teaching in a four-month computer science course at the Institut Pasteur, we decided to explore how to adapt StreamLiner to become a more general purpose teaching tool. The course includes different modules, taught by different professors, each with different materials and assignments. Students ranged from Ph.D.-level biologists, who need a computer science qualification to complete their degrees, to senior biologists who felt they needed to learn how to program in order to conduct their research.

In addition to obtaining assignments and course information on-line, via email or wikis, all students were required to record their work in an electronic notebook, either an informal blog or an HTML file. Electronic notebooks are clearly helpful for both students and professors in keeping track of the progress of the work. However, such notebooks are primarily designed to support the *capture* of information and do not provide effective ways to visualize or interact with it. StreamLiner's ability to handle multiple heterogeneous streams of activities or events makes it an interesting candidate for interactive visualization of course materials.

We decided to show StreamLiner to professors who had taught the course, to understand how StreamLiner could be used as an interactive course visualization tool, and to explore ideas for the future.

Interviews

Participants: We interviewed three professors who had organized and taught the course. The first professor had been responsible for managing the whole course, from its creation. The other two professors were a senior biologist and a senior bioinformatician who were each responsible for major components of the course.

Procedure: We visited participants in their labs and asked to see the electronic notebooks they had assigned students to use during their part of the course, either an HTML notebook or a blog. They showed us examples of from individual student notebooks and described how they managed the organization of the course. Each also explained how they followed each student's progress and communicated with students.

We also acquired the electronic notebooks of seven students, drawn from two different years when these professors taught. We selected data, such as the student's names, project descriptions, and activities, and converted the data into a format usable by StreamLiner. This post-hoc conversion took a few hours and required a several small modifications to the data format.

We then asked each professor to try StreamLiner and reflect on how it might help them manage the diverse course data, from agendas and assignments, to notebooks and on-line projects. We found that using real course data was important for encouraging the professors to actively engage with StreamLiner and resulted in a number of suggestions and directions to pursue in the future.

Results

Information overload: All three professors commented that the existing electronic notebooks provide too much detail. They appreciated StreamLiner's ability to provide an overview of each individual students' progress, which is helpful for identifying problems such as missed assignments or periods with no activity. They felt that this was necessary for knowing when to intervene with a suggestion or to leave the student on his or her own. The professors also liked the overview of all of the students in the class, to flag inconsistencies and to compare different work patterns.

Tracking activity: One professor, who used RSS feeds as a way of examining the student's blogs, commented that StreamLiner's format was much more accessible. He liked the combination of seeing an overview of all the students, combined with the ability to filter information and zoom into relevant detail.

Communication medium: StreamLiner can be used as a direct communication tool, allowing professors to monitor and comment directly on specific notebook entries. The professors liked the idea of a targeted notification system, since it would help the teaching staff be more responsible and help to prevent students from getting lost. More generally, they wanted to add additional streams, such as seminars, celebrations and special events, as an integral part of communicating with the course participants.

Teaching tool: Students arrive in the class with a wide range of experience with lab notebooks. Some have used them for years and are disciplined and efficient at recording their work. Others have never used lab notebooks and do not see the point of using one for a programming project. One of the professors made a point, at the beginning of each course, of explaining his personal approach to using a lab notebook and showing students examples from how students in previous years. StreamLiner offered him an effective way of showing how a particular student progressed through the course and showed how effective use of a lab notebook can catch errors and avoid unnecessary work.

Comparing across years: Another advantage of StreamLiner is that it makes it easy to compare notebooks from one year to the next. For example, students used a blog format one year and an HTML-style notebook the next. StreamLiner treats each as a stream of events over time, making it easy to, for example, compare how students performed on the same assignment in two different years.

Suggested extensions

In addition to the above features, which are currently available in StreamLiner, the professors also suggested the following:

Comment feature: to allow professors to make suggestions, ask questions or mark errors in the students' notebooks.

Published event streams: to publicize seminars, seminars and events to special interest throughout the course.

Meeting calendar: to organize students' project activities or bring together members of a particular lab. This can easily be accomplished by integrating XML-based RSS feeds.

Advanced filtering: to provide finer-grained management of activities or subgroups of people.

Perspective views: to provide additional views, such as progress charts that show statistics or percentage completed of a particular project.

6. Summary and Future Work

StreamLiner provides a time-based approach for viewing students' activity over time. Professors can see both an overview of all of the students' work, and also navigate to find more detailed information, such as particular results from a lab exercise. StreamLiner also supports comparisons across different types of data, collected in different years.

Teaching, in almost any subject, relies increasingly on on-line material, either in the form of information provided by the professor to the students, or work done by students and provided to the professor (or to their peers). Current techniques, such as blogs and wikis, enable professors and students to exchange information in a lightweight way. However, the information is generally organized in a linear way and it becomes increasingly difficult to find anything as the quantity of material increases. StreamLiner provides a simple and effective way of visualizing information captured in blogs, wikis, and other forms of electronic notebooks.

In the future, we plan to create a more general-purpose version of StreamLiner that can support any type of course resource, from students' paper notebooks to digital notes. We also plan to transform Streamliner from a desktop application to a collaborative web application. This would allow professors and students to share views of their activity while maintaining control. Students could easily share events, notebooks entries comments to their professors, laboratory partners and other students. Professors and tutors would be able to publish their teaching material, such as lecture slides and handouts, but also share their plans and meeting availability. Finally, we plan to explore new features that allow professors to set up new courses based on the previous courses they taught, create new teaching programs and compare pre-defined plans with actual practices.

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