# ButterflyNet: Mobile Capture and Access for Biologists

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**ABSTRACT**
Biology fieldwork generates a wealth of qualitative and quantitative information, an unstructured "bag of data" that requires substantial labor to coordinate and distill. Currently, a gap exists between the field tools used to collect data and the laboratory tools used to search, analyze, and share that data. The ButterflyNet system we are building bridges this gap by providing efficient interfaces for searching, managing, and sharing biology research. We present two aspects of ButterflyNet: the ability to view field notes presented alongside photos that are correlated in time, and the ability to share that view with a colleague.

**Keywords:** Augmented notebook, mobile capture/access.

**INTRODUCTION**
Biologists who work in the field and the laboratory face a difficult task of managing and searching through vast amounts of information. Technology exists to support data collection: biologists use paper notebooks, digital still/video cameras, audio recorders, environmental sensors, and custom-built monitoring devices to collect experimental data. However, there is limited support for organizing, searching, and sharing that information. Much valuable research remains locked in paper notebooks or in digital storage "bins." ButterflyNet addresses this by enabling biologists to organize, search, and share their notebook data and related media.

**Field Study**
We began this research by conducting 23 interviews with biologists from the Department of Biological Sciences at Stanford University, the California Academy of Sciences, and the Jasper Ridge Biological Preserve (JRBP). As part of the contextual inquiry, we observed biologists using their field/lab notebooks and photographed and analyzed 471 pages from 13 notebooks. The first author joined Jasper Ridge as a docent, both to connect with researchers and to become fluent in their language. Currently, he is leading a research project at JRBP to evaluate digital camera traps. The first author also conducted a pilot deployment of our technology in the Los Tuxtlas rainforest in Mexico. He lived with 12 biologists for nine days, and helped with their experiments on various aspects of tropical plants.

**Figure 1.** Four biologists hike rugged terrain between remote sites. Technology for field biologists must survive these harsh requirements.

Our main finding was that paper notebooks are the central organizing artifact for biology research. Paper notebooks are robust, portable, and readable in the sun. They are easy to browse through, and have "infinite" battery life. They provide a flexible input interface. In the notebooks, we observed written procedures, sketches, pasted-in charts, and

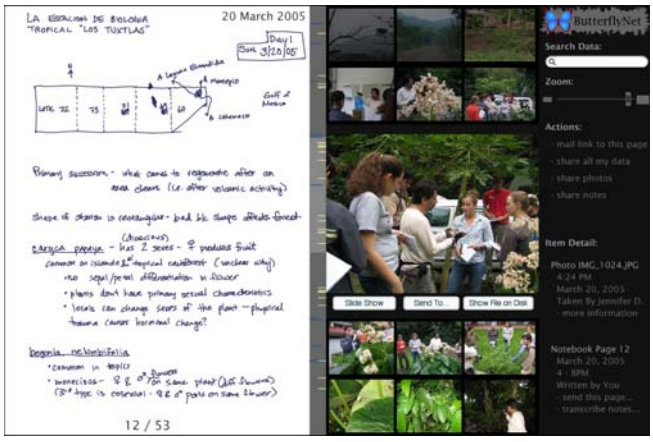


**Figure 2.** The main view shows a notebook page with temporally-related photographs in a side panel. As the user navigates the digital notebook using the scrollbar (center, with overlaid visualization), photographs will appear/disappear depending on how closely they relate to the visible page.

even napkins containing notes. However, paper does not provide any benefits of digital media: immense storage, fast search, flexible visualization, and efficient sharing.

### Benefits

ButterflyNet complements current practices by presenting digitized notes with heterogeneous data types in a search & browse interface where data correlated in time and space are visualized side-by-side. It allows biologists to more efficiently find data such as photos, notes, sensor data, and audio/video. They can then share this data with colleagues.

We are developing techniques to transform data from field notebooks into analyzable, searchable forms. For example, one ornithologist reported that he generated more than ten field notebooks over a season. These notebooks take him twenty hours a piece to transcribe into a database. Thus, six months of field season data can require 200 hours to collate and transform into a usable form. From this, and other observations, we discovered that data transcription is an important task to streamline. A pilot study of our data transcription technology showed modest improvement in manual data transcription. We are currently designing techniques to further improve the speed and accuracy of both manual and semi-automated data transcription.

We are also developing techniques to navigate and visualize the flow of data throughout the life of a research project. Providing the ability to backtrack through the data lineage allows scientists to explore outliers and verify observations.

## BUTTERFLYNET USER INTERFACE

ButterflyNet allows biologists to share their notebooks and photographs with colleagues. The following scenario demonstrates how Roger, a researcher studying plant-animal interactions in the Los Tuxtlas rainforest, can share his work with Karen, a colleague in her campus office:

Roger researches the interactions between Leafcutter Ants and the *Astrocaryum mexicanum* palm tree. In the field, he brings an Anoto digital pen, paper notebook, and a digital camera. He records observations of behaviors in his notebook, and takes accompanying photos to illustrate them. Back at the field station, he uploads his notes and photos. He starts the software, selects "Share with Colleagues," and the system uploads the new note pages and photographs to the ButterflyNet server. Karen can then connect to the server to browse Roger's notes. As she views different pages, accompanying photos will be displayed in a side panel, as the photos have been automatically correlated with the notes via time stamps (see Figure 2).

Each ButterflyNet user's software maintains a local database of time-stamped notes and photos. The sharing feature uploads data to a central server. For each note page, the server computes good candidate photos to show, based on similar time stamps. When a user later views a page, these candidate photos are displayed in a side panel.

## RELATED WORK

The ButterflyNet design as a notes-centric capture and access system is informed by a number of capture and access systems for personal and shared notes, including AudioNotebook [7]. The aspect of merging paper and electronic media is inspired by earlier designs in this area [1, 3-5]. Notably, Mackay *et al.*'s a-book is a notebook for laboratory biologists integrating a paper notebook with a PDA, which is used to create a table of contents and links from pages to external data sources [6]. We also leverage research on low-power, wireless sensor networks, which have been deployed in the environment to monitor field sites that are remote and/or difficult to manage [2].

## CONCLUSION AND ONGOING WORK

We have described ButterflyNet, a mobile capture and access system for biologists to share notebooks and photographs with colleagues. Colleagues can use the interface to view notebook pages, which are presented side-by-side with photographs taken at similar times. This side-by-side presentation is generated automatically by the system, which correlates objects with similar metadata.

Currently, we are building the infrastructure and interfaces that allow a richer set of media to be collected, managed, and shared. ButterflyNet will be able to correlate notes, photographs, audio, video, GPS data, and sensor net data.

This project is open source, and can be downloaded at http://hci.stanford.edu/research/biology.

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