
Integration of Handwriting Recognition in Butterfly Net

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Abstract

ButterflyNet allows field biologists to organize and share their multimedia data easily. By integrating handwriting recognition into the system, a lot of additional functionalities can be implemented to further facilitate the process of data organization and sharing. In this paper, the search functionality is investigated and a prototype that enables searching through handwritten notes is implemented and tested.

Keywords

ButterflyNet, Handwriting Recognition, Search

ACM Classification Keywords

H.5.1: Multimedia Information Systems—artificial, augmented, and virtual realities. H.5.2: User Interfaces—Interaction styles, prototyping, screen design.

Introduction

ButterflyNet is a system designed to facilitate the collection, organization, and sharing of multimedia data [1]. Using the system, biologists can capture and review all data from field studies (e.g. handwritten notes, digital photographs, and video clips) in a single browser, with different types of data associated with each other using their timestamps. To further enhance the process of data sharing and organization, especially

for handwritten notes, handwriting recognition is implemented in ButterflyNet. With the integration of handwriting recognition, a lot of additional functionalities can be employed:

1. Text conversion— Handwritten notes can be converted into a format that can be edited and exported. This can save time in the transcription of data and can produce clear and legible notes.
2. Search— User can retrieve information from a large amount of notes easily by running a search. This functionality helps support the sharing of data among multiple users. For example, one can combine notes from different biologists and retrieve relevant information easily by running a search according to keywords instead of reading through several notebooks.
3. Hypertext network— Keywords can be recognized and linked to relevant information in other pages or in a dictionary.
4. Export of data— With handwriting recognition, data can be exported to other applications such as Word, Excel, and Outlook express for processing or sharing.
5. Creation of database— A database of notes can be created for easy organization and storage of data. Keywords can be used to index into the database. Without handwriting recognition, queries can only rely on filenames and dates.
6. Spell check— With handwriting recognition and a biology dictionary incorporated, spell check can be implemented to improve the accuracy of the notes.

This paper focuses on the search functionality because it supports one of the main design goals for ButterflyNet— facilitation of sharing of data among multiple users.

Design

The three main concerns in the design of a search interface are the ease of use, the accuracy and usefulness of the search, and the display of the search results.

Ease of Use

The interface should be easy to use, without requiring former training. One of the ways to achieve this is to model the interface after web search interfaces, because most people are already familiar with such interfaces.

Accuracy and usefulness of search

The usefulness of search can be evaluated by two criteria—the relevance and the completeness of the search results. This is a difficult problem in searching through handwritten text because errors are introduced during the stage of recognition.

Display of search result

In order for the system to be useful, search results should be arranged and displayed in a way that provides most information to the user. A major difference between web-based search and notebook-based search is that the latter has more hierarchies— pages returned can be grouped under notebooks, which in turn can be grouped under users. Other groupings such as dates can also be used. Displaying search results according to relevance (scores returned by the

User Study

A user study with six participants was conducted to test the interface based on the three criteria described in the design section—ease of use, accuracy of search, and display of results. Since ButterflyNet is designed to aid biologists in field research, participants were asked to play the role of biology students who wanted to retrieve information from notes taken by two different biologists at the same field study. They first skimmed through the first few pages of each set of notes to get an idea of what the notes were about. After that, they were asked to do a search on four previously chosen words that appeared on the first few pages and four other words of their own choice, and evaluate the search results and the user interface.

Most participants liked the interface for its simplicity, ease of use, and its resemblance to the Google interface, but agreed that a lot of additional features should be added to make it more useful. In terms of search results, all participants except one were satisfied with the accuracy of the search and some were impressed that it worked even with sloppy handwriting. As for the display of search results, while most agreed that results should be grouped according to user or notebook, some thought that page ordering was more important than the relevance as evaluated by the search engine. There was also a wide range of opinions on the usefulness of thumbnails. Some thought that it would be better to show just the area around the matching word on the page, while some thought it would be enough if matching words were highlighted on the thumbnail.

Additional Features

Here is a list of additional features that may be implemented in the future, based on design ideas that have not been employed and comments from user study:

1. **Highlighting**— Matching words on a page should be highlighted. Almost all participants agreed that this is an essential feature, and would greatly reduce the time to go through the notes.
2. **Advanced search options**— User should be able to narrow the search to only consider certain user, notebook, or date.
3. **Search multimedia data**—ButterflyNet allows data of different types to be associated with each other by their timestamps. This association can be used during search. For example, pages containing the matching words as well as pictures taken around the time those words were written can be retrieved together.
4. **Zooming in on notes or conversion to recognized text**— Some participants commented on the legibility of the notes. This could be an issue when reading someone else's handwriting. Both zooming and conversion to recognized text might increase clarity.
5. **Ranking based on context of match**— When taking notes, many people would underline important words or write them in bigger font. Both should give the match a higher score during search.
6. **Did you mean?** — The 'did you mean?' functionality is basically a spell check on the query. Although this is implicitly implemented using Fuzzy search, explicitly correcting the query can potentially improve search results.

7. Tabbed panel— Having each page appear on a new tab may be useful for user who wants to refer to a previous result.

Related Work

Similar to the ButterflyNet system, the Logitech io2 Digital Writing System [4] consists of a digital pen, paper, and software that convert handwritten notes into text. The software used, MyScript Notes, has a recognizer that can recognize natural handwriting as well as geometrical forms, arrows, and tables. This kind of recognizer can be very useful for ButterflyNet given the large amount of drawings and tables in biology notes. However, MyScript does not provide other functionalities such as search. It also does not support multimedia which is the major contribution of ButterflyNet.

EverNote is another software that supports the Logitech io2 Digital Writing System. Of all the commercial products I found that involve handwriting recognition, EverNote [5] seems to be most similar to ButterflyNet. It supports notes of different types, such as text, handwriting, and image clips. It also supports search by time, categories, and keywords. An advantage ButterflyNet has over EverNote is that it enables automatic association of different types of data according to their timestamps, which offers the potential for multimedia search using just keywords, as described in the previous section. However, EverNote's capability of organizing data by time, category, and keyword, and its ease of exporting data are areas we should look into for ButterflyNet.

Other modes for inputting queries should also be investigated. For example, Scribbler [6] is a tool that enables user to search unrecognized handwritten notes by circling the word to be searched on the notes or by writing the query by hand. Search is then done using shape matching. Although with a good handwriting recognizer, this method may not be necessary or useful, it suggests that there could be other modes for inputting queries, such as handwriting or maybe speech.

Conclusion

Integration of handwriting recognition into ButterflyNet opens the door to many additional functionalities, one of which is search. While user testing of the prototype implemented gives mostly positive results, there are many areas that need more work. For example, currently, strokes are segmented into words using their timestamps. A better segmentation technique, such as one that could differentiate drawings from text, can probably improve the recognition result. In terms of the search interface, the display of search results is the area that needs urgent attention. Based on comments from user study, it seems that a good way would be to group results according to user. Within each user's notebook, results should be sorted according to page number, with the score indicating relevance shown on the side. Another way is to provide different sorting options, similar to how files in a folder can be sorted by name, date, or type. Lastly, the list of additional features listed are definitely areas to look into.

Acknowledgements

I would like to thank Professor Scott Klemmer and Ron Yeh for their invaluable advice, support, and help.

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