Generating Views of the Buzz: Browsing Popular Media and Authoring using Mixed-Initiative Composition

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ABSTRACT
combinFormation's mixed-initiative composition space enables system agents and humans to engage in processes of finding relevant information, and forming and authoring collections. Previously, the system was developed and utilized to support information discovery. The efficacy of the system for supporting creativity has been established in some contexts.

We present combinFormation as a tool for browsing popular media and authoring personal collections. Yahoo Buzz is an institutional collection of top search queries, categorized into genres such as actors, music and sports. Existing interfaces limit the user to only viewing results of a single search at any given time. This paper presents a new system structure which interleaves multiple searches concurrently in a round-robin manner, enabling users to concurrently explore and browse diverse result sets. The mixed-initiative composition space serves as a media interface for combining search results and authoring personal collections. Evaluation using the Buzz demonstrated that participants were able to browse more diverse information using combinFormation than with a typical browser. They experienced browsing and authoring as easier and more entertaining. The results have implications for a broad range of user contexts in which combined views of the results of multiple searches need to be authored, including research scenarios, as well as popular media.

Categories and Subject Descriptors
H.5.1 [**Multimedia Information Systems**]

General Terms
Algorithms, Design, Human Factors.

Keywords
personal collections, information recombination, search interfaces, information discovery, exploratory search

1. INTRODUCTION
We live in a global village of popular media [19]. Media are extensions of human senses, representing information in forms that human beings perceive and respond to. Popular media – such as newspapers, television, movies, and magazines, web sites, search engines, blogs, instant messenger, and emails – weave the fabric of society. They define our cultural context. They have predominately replaced traditional cultures as sources of significance. Popular media also serve to represent individuals' significant experiences, when experienced in personal contexts. Digital information takes center stage. Manovich calls for the creation of new media objects that "aestheticize" information processing through navigable space [17]. The present research responds to this call.

Yahoo! Buzz is a web site that presents the top search queries made by users on the Yahoo! Search engine. This is calculated as a Buzz score; where each point is 0.001% of users searching Yahoo! on that day [30]. The top Buzz areas are modally categorized as Leaders (most searched subjects on that day) or Movers (greatest increase in Buzz score from one day to the next) on six topics: Actors, Movies, Music, Sports TV and Video Games. Thus, users who are interested in popular media can use Buzz to access the day's most popular topics. Considering the choices offered by the Buzz site as a whole, with many searches in each category, results in a large set of potential information resources for the user to browse through. With the Yahoo! Buzz interface, for each category, the user can navigate from the list of top search queries to the search result pages and then to actual result documents, giving them a taste of the day's most popular content on the internet.

The problem is that existing browsing interfaces limit the user's experience because she needs to wade through this enormous information space page by page, click by click. Every new page leads the user to new content, but severs them from the context of the previous page. This visual disconnection makes it difficult for the user to compare, connect and relate informational content that they have been exposed to from different sources. Adding to the users' woes, a session of browsing is ephemeral. There is little to show for the time spent except for personal memories, the hardly navigable browser history, and perhaps a bookmark or two.

We present combinFormation as a tool for experiencing popular media. combinFormation integrates searching, browsing, collecting, mixing, organizing and thinking about information. Visual media elements are extracted from documents and combined visually in the form of a composition, while functioning navigationally as bookmarks. The present research develops a refined control structure for generative searching and browsing. We also develop a new system structure, the *ResultDistributor*, which interleaves multiple searches to process large collections of searches and documents in the order that makes sense for the user. For example, for each Buzz topic and modality, combinFormation receives the set of the top 15 search queries. To represent this collection of searches to the user, the system will need to retrieve the first 15 result documents for each search. With the integration of the new structure into the combinFormation interface, a single composition space serves to represent and connect the 225 documents that result from each Buzz area. Further, multiple areas can be combined. Users experienced this representation as easier to use, more interesting, entertaining, and were able to explore diverse information than the typical browser interface.

2. MIXED-INITIATIVE COMPOSITION

combinFormation is a novel mixed-initiative system that integrates searching, browsing, and exploring information on the Web [7][12]. System agents generate media element clippings, which are extracted from documents, and assemble them visually and procedurally. The media composition develops over time, like a dynamically generated video. The user engages in processes of browsing, collecting, and authoring media in the composition space. When the user mouses over a media element in the composition space, semantic metadata details-on-demand are visualized. Users can directly experience the juxtaposed media element clippings, and they can also navigate back to source documents for more in-depth information. Design tools are also available on mouse-over of the element, providing users with capabilities for creating and authoring their own personal collections as navigable media compositions. While users are browsing and manipulating media elements, they can also express interest to direct the human-in-loop system to retrieve more relevant information.

This section presents a new control structure for

Figure 1. Google's OR search results from a query, "apple OR orange". It only brings two results from orange out of ten search results in the first page.

combinFormation's processing of multiple searches, extracting media clippings, and generating compositions. We improved the human-in-loop experience with a new interest expression interface, to provide users with better continuous control for retrieving relevant information. An application of the proposed structure and interface is to advance people's experience browsing massive amounts of popular media from many sources.

2.1 ResultDistributor

combinFormation can be used to issue multiple searches at one time, in order to combine and integrate results [12]. The Buzz scenario is an extreme case of search combination. We combine searches with separate queries to search engines, instead of combined "OR" searches, in order to meet the user's information needs. Typical search engines allow "OR" searches to gather different information in one space, but they show the results of the "OR" searches in page rank [2] order of the total set of search results, without giving equal priority to each search query the user initiates. Example search results of a query, "apple OR orange", in Figure 1 show that most of search results are from "apple" and few are from "orange". Because "apple" is more well-known company than "orange" and many web pages are referring the "apple" sites, it is obvious that "apple" sites have higher rank value than other "orange" sites. However, what users expect when they explore multiple searches are distributed results from all queries.

What is the appropriate structure for processing multiple concurrent searches? In combinFormation, several concurrent threads are retrieving search results. If we naively queue searches, and then simply download result documents as the results arrive, the order of arrival of documents will be heavily biased to the first searches that are issued. Another problem is that the connection and read times vary across result pages. Inasmuch as the user wants to compare and integrate information from across the searches, this behavior is unacceptable. We need a control structure that gives information from each search equal weighting in the retrieval order and presentation.

The ResultDistributor structure is developed to combine results from multiple searches equally. It processes multiple searches like a round-robin scheduling algorithm. It assigns equal priority to each search and handles search results in order. For example, the first result from the first search query will be processed equally with the first result of the second search query, even though the page rank order of the two search results are different. This control structure adjusts the order of downloading and processing in breadth-first manner to even out the searches' media contributions.

The first step performed by the ResultDistributor is to request all of the searches, in order (see Figure 3). The ResultDistributor builds a data structure dynamically based on the number of search queries and the number of search results returned by the search engine(s) (see Figure 2). The number of search results may vary across different search queries. This will be recognized while processing searches, so the ResultDistributor can be aware of how processing proceeds for each search, and when it needs to terminate. While it processes searches, results are inserted into a ResultSlice structure. The *ResultSlice* is a data structure that contains results of the same ordinality from multiple searches. The first results of all searches are inserted into ResultSlice 1. The

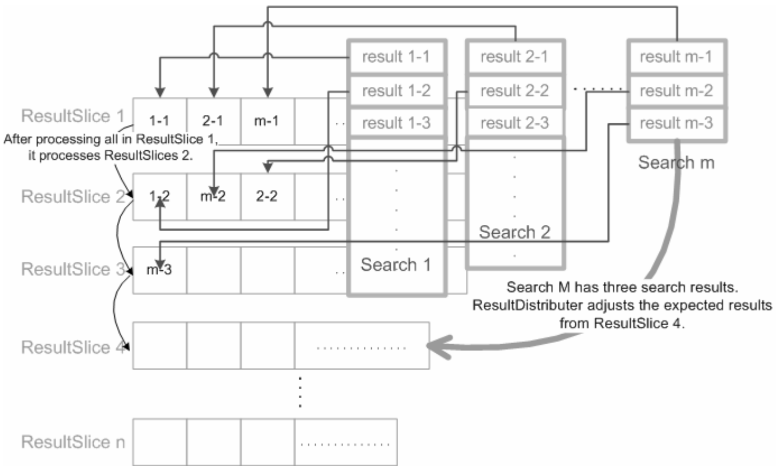

Figure 2. Three concurrent processes in the ResultDistributer: (1) Process Search: add results into the appropriate ResultSlice; (2) Process Result: download and extract media from results in the ResultSlice. Move to the next ResultSlice after it finishes all results in the current slice; (3) Adjust the expected number of results in each ResultSlice.

```
Input      : Search Queries (m)
Output     : Distributed Media extracted from Results
Procedure  : Start -> Process_Search(Qi) where 0 = i < m
             Start -> Process_Result(a, b) where a=0, b=0

Process_Search( Q ) {
        i=0;
        while( !downloadDone ) {
                Result = Q.parseNextResult();
                ResultSlice[i].add(Result);
                i++;
        }
        doneResult.add(i);
}

Process_Result( a, b ) {
        if( b < ExpectedNum(a) ) {
                Page = ResultSlice[a].get(b);
                Page.extractMedia();
        } else {
                a++;  b=0;
                Process_Result(a, b);
        }
}

ExpectedNum( n ) {
        if( doneResult.remove(n) != null )
                return (-- m );
        return m;
}
```

Figure 3. Pseudo code for the ResultDistributer.

second search results are inserted into ResultSlice 2, and so on. After all searches have been queued, and as they are being processed, processing of the first ResultSlice begins. Multiple concurrent worker threads are processing multiple searches; it is not deterministic which search results will be downloaded and processed first. Thus, results inserted into a single ResultSlice will be processed by the worker threads in a first-come, first-served manner. However, the next slice will not begin until processing the current slice completes.

The worker threads process search results starting from ResultSlice 1. They move progressively to the next ResultSlice as they finish processing the expected number of search results in the current ResultSlice. Let's assume that there are *m* searches, as in Figure 2. Consider a state in which the threads are processing ResultSlice 1, and it contains only *3* results. In this case, the expected number of search results in ResultSlice 1 is *m*. The current size of the ResultSlice is *3*, so the ResultDistributor will wait until it finishes processing the remaining *m-3* results in ResultSlice 1 before it goes to the next ResultSlice.

It is important to continuously track the search processing status, because the order of result processing depends on the expected number of searches in each ResultSlice. When a particular search finishes processing all of its results, it notifies the ResultDistributor to adjust the expected size of appropriate ResultSlices (Figure 3). For example, 'Search m' in Figure 2 has only three results, so the expected number of search results from ResultSlice 4 should be decreased by one. Even when a search engine is unavailable, the rest of the searches can be processed under this structure. Either each read completes normally or exceptions, such as connection timeout, of problem search pages cause notification to the ResultDistributor.

The ResultDistributor structure supports multiple searches either using a single search engine, or with a combination of different search engines. combinFormation can apply this structure in processing multiple queries from diverse search engines selected by the user, such as Google, Yahoo, Yahoo image, Flickr, and del.icio.us.

2.1.1 Composition of Image and Text Media

combinFormation represents information with composition of image and text media extracted from documents. Combined image and text representations have been shown to be a more effective format for cognition [1][5]. Composition connects elements visually. This representation format supports users in directly accessing and browsing media on the Web without clicking links. For example, a user needs to follow several links to get an image that she is looking for with a typical browser. However, using combinFormation, the visual composition agent processes searches, crawls links, extracts the image for her, and generatively combines it with other relevant media in the composition space (see Figure 4).

Image and text media elements are extracted from documents while searches and results are processing, and those elements are added into candidate pools. The visual generation threads select image and text media from the candidate pools, and present them in the space continuously and gradually. The candidate media are selected for display based on the weights, which are determined by the media semantics model (see Section 2.4.2). A carefully tuned multi-threaded control structures supports the mixed-initiatives. While the visual threads are active and searches are being processed, the user can concurrently access media, in-context details on demand, navigate to source documents, and manipulate design (see Figure 5, Figure 6).

2.1.2 Yahoo Buzz with ResultDistributor

The ResultDistributor processes Yahoo Buzz in combinFormation. This allows users to browse popular media from all the top search queries in an area at one time. combinFormation reads the Yahoo Buzz RSS feeds, which provide the fifteen top search queries for each topic and using either Leaders or Movers. It processes fifteen

Figure 4. Browsing TV Leaders in Yahoo Buzz with combinFormation. Large texts in rectangle boxes are labels added to identify the search queries of underlying clustered media elements.

search results from fifteen top search queries in a ResultDistributor structure. Thus, the system immediately handles 225 web pages at a time and extracts media from them. Figure 4 presents a combinFormation session that resulted from the topic 'TV Leaders' in Yahoo Buzz. A user can directly browse top media without clicking links.

2.2 Searching and Crawling Control Structure

Marchionini and Shneiderman characterized the difference between searching and browsing by the focus of the task [18]. Searching was characterized as more directed and focused, while browsing was described as an exploratory, information-seeking strategy that depends on serendipity. When people browse and explore information, they search with multiple queries and browse from search results [29]. To assist people's browsing popular media, the system needs to be directed to the popular media through search, and then explore from that point by browsing. Like a user engaged in exploratory search, combinFormation's focused web crawler follows links to download more documents after processing a set of searches is complete. A media semantics model that incorporates the user's interests drives algorithmic decision-making about which links to follow.

We refined the searching and crawling control structure of combinFormation to assist users. The system has four seeding threads for processing search results and two crawling threads for processing out-links from result pages. The seeding threads have higher priority than the crawling threads. When combinFormation starts up, only the seeding threads are running for processing search queries and results. The crawling threads start running when the seeding threads finish their jobs. The crawling threads continue, collecting information by focused crawling in a low priority while users are interacting with media in the composition space (see Figure 5).

We integrated a services server framework in combinFormation in order to perform requests from users in the middle of the session. Users are able to send a request of mixing or replacing search queries while combinFormation is running. In the services server framework, the DHTML web browser interface acts as a client. It sends messages via TCP/IP to the combinFormation services server. The messages specify retrieval and composition of media clippings from source types such as Buzz requests, direct searches, and RSS feeds. Search requests are processed by the seeding threads; during this processing, crawling threads are temporarily paused. These searches are also processed with higher priority than crawling so as to respond to users' search request promptly.

Again, this corresponds to the interleaving of searching and browsing that a human user would engage in (see Figure 5).

While the system threads are searching or crawling, new relevant media elements are continuously extracted and added into candidate pools. A candidate pool size threshold is maintained by periodically pruning low weight media elements. As part of visual composition space generation, new media elements are selected from candidate pools and composed. Users are concurrently able to interact with visual media in the composition space (see Figure 5).

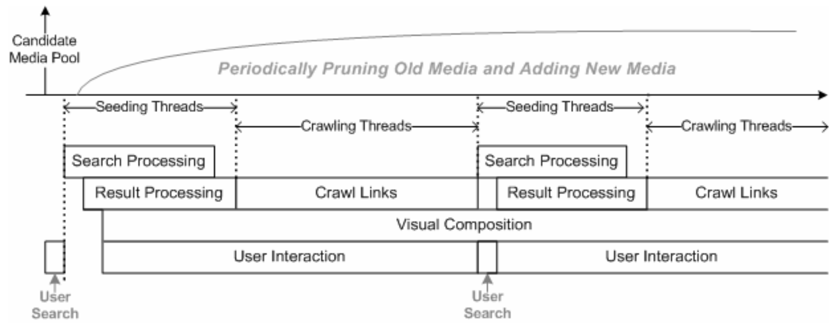

Figure 5. Control in Searching and Crawling Structure

2.3 Visual Clustering and Aging

Figure 4 presents an example of how combinFormation presents media elements in the composition space. Using the semantics of each media element, the system places related media in mutual proximity to generate visual semantic clustering [13]. Media from the same searches contain common semantics, so they have high probability to cluster together. What users see while they are browsing popular media from Yahoo Buzz is 15 generated semantic clusters of media from top searches, like in Figure 4.

A composition with many overlapping media in clusters could be difficult to read, as they compete with each other visually for human attention. Visual aging is a technique in which the prominence of elements is diminished gradually, as they are presented over time in the composition. The system periodically imparts visual aging onto the media in the composition space. For text media, visual aging is constituted through growing transparency (decreased alpha). For image media, it is accomplished through gradual desaturation, in which colors seem to drain to gray. Full color and opacity are restored for the media when it is brushed, that is, on mouse over, along with the display of in-context metadata details on demand (Figure 6). Since expression of positive interest in an element is a sign that it is significant to the user, such expression suspends visual aging for a given element.

2.4 Human-In-Loop Information Exploration

An interest expression interface and a media semantics model are connected in combinFormation to support human-in-loop exploration. Interaction and computation work together to learn about and support the goals of the user. A recent study examining agents in search engines and information systems reported that agent searching is similar to human searching; it is not substantially more sophisticated than that exhibited by human searches [10]. The system agent alone cannot meet a human's sophisticated media needs. The human needs can be articulated in the loop of the retrieval and composition processes to direct the agent through interaction. An important issue here is how and when to communicate or instruct agents to change their future behavior, and by which mechanism.

2.4.1 *Interest Expression Interface*

To support human-in-loop information exploration, we developed a new interest expression interface, the in-context slider, which requires minimal effort to use, and so increases the willingness of users to express interest [28]. The in-context slider interface recognizes aspects of the user's situated task to provide transitory affordances in proximity to the focus object to support the adjustment of a value through fluid movements. A user's decision about the relevance of information occurs while that information is in the user's focus. Having an interest expression mechanism appear in-context allows the user to express interest immediately and directly.

To express interest with an in-context slider, the user moves the mouse cursor up or down over the slider. All bars from the navel (center) to the current mouse position are highlighted with the appropriate color (see Figure 6). A small popup textbox with the current visualized value appears to the side of the slider vertically matching the current mouse position. Once the desired value is visualized, the user clicks the left mouse button to set the value. The user can choose not to change the value by simply moving the mouse off the slider without clicking.

The interest value changes are reflected with colors to users. The current interest value is highlighted with hue in the slider bars. Positive interest values are represented in green, and negative values are in red. The neutral values are represented by gray. The

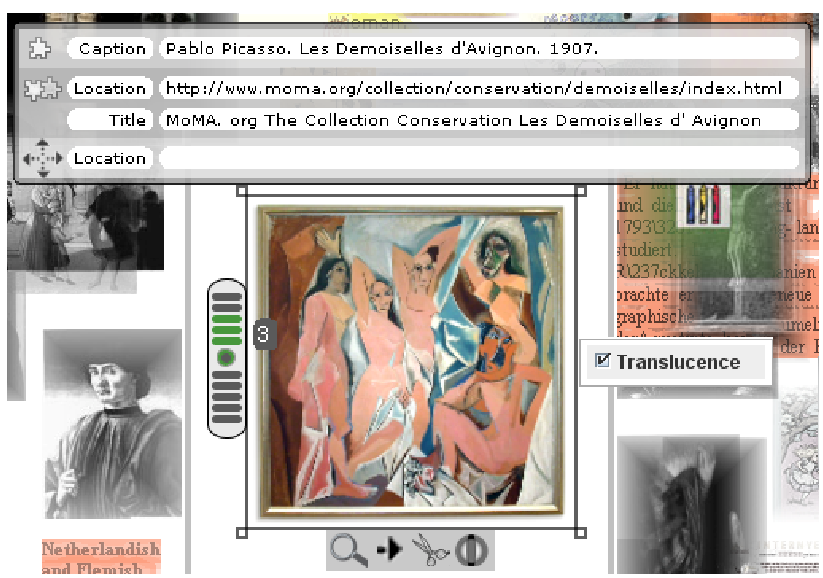

Figure 6. In-context interest expression interface activated on mouse over a media element.

saturation visualizes the intensity of interest. For example, a value of five will appear greener than a value of one. The same applies to negative values with the color red. When the in-context slider is not fully expanded, the navel component visualizes the current value with the same hue and saturation. The color of terms that are associated with the media of interest will also change to match the color for its assigned value. This provides quick feedback to the user about the currently assigned value. This expression of positive or negative interest in an element adjusts weights in the media semantics model.

2.4.2 Media Semantics Model

The media semantics model represents the structural relationships between source web pages, the media elements extracted from the pages, associated metadata, and hyperlinks. One top-level component of the model is based on the hypermedia graph, which represents the referentiality of the authored and dynamically generated hypertext of the World Wide Web, and of the user's filesystem. Another primary model component is based on the vector space model of information retrieval (IR) [25]. It uses common terms to connect all the media in the visual space and candidate pools. Features come from the semantic web, digital libraries, information extraction algorithms, and user annotations. The media semantics model works in conjunction with human expressions of interest to manifest relevance feedback [24]. Metrics that utilize features and relationships of the media semantics model compute weights that drive the agent to act on behalf of the user [12]. The system agent employs the metrics in algorithms that select new media to present in the composition space from pools of media candidates, select web pages to crawl, and select layout positions of the new media as they are added to the visual composition.

When the human expresses interest in media, this expression is propagated through the model to semantically related media by spreading activation [23]. The media itself and terms in the media receive the interest activation. The interest activation spreads to the hyperlink page of the media, if there is one, which is the information resource that the media element most directly represents. If there is no hyperlink, a lesser amount of interest is propagated into the source web page. Candidate image and text media formed from this page also receive spreading interest activation. The in-link and out-link pages recursively receive the propagation spreads with a damping factor, to a 2nd layer.

These propagated interest expressions contribute to the weighting metrics the system utilizes in its generative collecting and visualizing initiatives. These measures govern the choices of pages and images downloading by the information collecting, selecting media from candidate pools, and also affect the visual representation of media. The system uses interest expression while computing weights to choose size, and arrange the layering of media in the visual composition space over time. Likewise, interest expression impacts how media elements age visually.

2.5 Authoring Collections as Compositions

The main human-centered activities in multimedia are media production, annotation, organization, archiving, retrieval, sharing, analysis, and communication [9]. combinFormation provides tools to author and produce creative media collections as compositions. Using the design tool, users can organize and manipulate by rearranging, changing size and transparency. They can annotate by creating or editing texts with different colors, font sizes and styles. While browsing, they can also author by dragging and dropping media elements from documents into the space by drag and drop. We developed a Firefox drag and drop extension, which brings associate the source URL metadata with the media into the composition space. This allows users to navigate back from each media element to its source web page.

In combinFormation, agent and human share the mixed-initiative composition space for media generation and authoring. Two structural mechanisms are provided for the human to control subspaces of the composition space: the cool space and the latch. A resizable cool region of the composition space, positioned in the center so as to make the human's actions primary with the agent's actions supporting, is reserved for only the human to collect information. The latch is an in-context tool, available on mouse-over of a media element, which enables the user to create the equivalent of a single-element floating cool region. Agent visual composition generation is limited to the hot region and will not remove, cover, or age any elements that the user places in the cool space or latches.

The produced media collections are archival or sharable by simply saving. combinFormation generates XML, HTML, and JPEG image files when it saves. Visual media elements and the media semantics model are stored in XML format, which can be reopened with combinFormation. A file in a dynamic HTML and JPEG format can be opened in a regular web browser. Both formats can be published on the web and shared with colleagues and students, which will initiate communication. The DHTML version is visually identical to the full combinFormation composition, and provides similar interactive in-context metadata details-on-demand and navigation to the source web pages. It includes a hyperlink at the bottom, which opens the full XML in combinFormation.

3. EVALUATION

To assess the efficacy of combinFormation for browsing popular media, we conducted a controlled experiment in which participants engaged in a browsing and authoring task using Yahoo Buzz. For each study condition, participants used either combinFormation or a typical toolset to browse and collect popular media. For the typical toolset, Firefox was used for browsing and Microsoft Word for collecting interesting media. For combinFormation, participants could browse and collect popular media with the same mixed-initiative composition tool. In the study, participants were asked rating and essay questions about their experiences. We also logged the URLs that they browsed using each toolset.

3.1 Study Apparatus

The Study apparatus involves components for presenting the Buzz, for presenting tasks and study conditions to participants, and for logging the participants' browsing activities.

For the experiment, we divided the six Yahoo Buzz topics into two subsets. This was to eliminate carry-over effects that could result from conducting the same task with same media, but using different toolsets in separate conditions. One subset contains Sports, Music, and Video Games; the other subset contains Actors, Movies, and TV. We created a front page for each subset and toolset, in which participants can select interesting topics for them to browse during the study. The front page contains six choices of the three categories with both Leaders and Movers. By brushing a topic with mouse over, the fifteen top search queries are activated to appear on the right side of the topic. Thus, during the study, participants could identify interesting topics for them to browse.

When participants clicked one of topics on the front page, it opened either combinFormation or Firefox in a new window, to present the fifteen most popular searches. The front page reads the live Yahoo Buzz RSS Feeds; however there was a JavaScript security problem of reading and parsing XML from the another host inside the browser. So, we created a servlet that reads Yahoo Buzz RSS with the topic as a parameter and outputs a live RSS string. The front page uses this servlet output to create dynamic HTML pages, and present participants the everyday updated popular media.

We developed the study apparatus using a framework for conducting user studies that is implemented with Javascript, Java Servlets, and XML. We defined the current experiment steps, counter-balanced orders, and resources in an XML file, and deployed the study to a server. The study Servlet rendered appropriate experimental conditions for each participant. It recorded times, conditions and other data. As each participant finished the study, data was stored in a repository in XML format.

There were two logging servers that recorded URLs participants browsed during the study. One was an HTTPPostServer, which processed HTTP Post messages sent from the browser. We used the Greasemonkey Firefox extension [6] to create a client resident in the browser to log every URL the user browses. This is more efficient and effective than using a proxy server. During a browsing task, the browser logging client accumulates entries for each user browse action. When the task finishes, it sends an HTTP Post message of the logs and a participant id to the logging server. The server saves the logging data in XML files. The other server was a combinFormation logging server, which records all the participants' interactions using the system. The combinFormation logging data is also saved in XML files.

3.2 Participants

Seven participants were involved in the study. They were college students, and their majors were three computer science, two general studies, one electrical engineering, and one economics. Only one of them used combinFormation before, and the rest of participants had never used combinFormation before. We asked about their browsing and internet usage patterns. Five of them said they browse and search more than once a day and two said daily. We also asked how often they browsed the internet with no specific tasks (casual browsing); five of them said daily and two of them said a few times a week. The demographic information showed that the students search and browse casually on a daily basis.

3.3 Procedure

Participants were seated in front of a computer system with two monitors. At the beginning of the experiment, the experimenter introduced what the study was about for approximately 2-3 minutes. Whenever the participants were not clear about the experimental procedure, they could ask questions. The experimenter also explained about what is combinFormation, and demonstrated how to use it, because all participants except one were using combinFormation for the first time. Then, participants started the experiment.

The study phases consisted of pre-questionnaire, core-study, and post-questionnaire. The pre-questionnaire asked about participants' background. Next, in the core-study, they performed two browsing and authoring tasks. The task was:

> "The page below shows 3 topics: Music, Sports and Video Games. The leaders are top queries in Yahoo for the day. The movers represent queries that have gained the most in the past day. Hold your mouse over a topic to see what queries the leaders and movers contain. When you have decided to proceed searching a category, click on the leaders or movers to start the search. If the current task is using combinFormation, the application will start. If this task requires that you use a browser with Microsoft Word, please open Microsoft Word by clicking on the icon on the Desktop. Collect any pictures or text that you find interesting. Reference appropriate information. Develop a collection that you could show to others to show your interests. Arrange the collection in combinFormation or in Microsoft Word in a way that expresses your interests clearly. If you are unhappy with what your searches are giving you, you may replace or mix searches with combinFormation by clicking another category. If you are using a typical browser, clicking another category will open a new window with new search. If the current task is using combinFormation, use the interest expression mechanism to get more relevant results. Express positive interest in useful things, and negative interest in unhelpful things."

Each task in the core-study took around 15-20 minutes. There were intermediate questions after each task. Before conducting the task with combinFormation, there was a brief practice session with combinFormation. In this session, participants used combinFormation for few minutes to browse news. The study concluded with a post-questionnaire, which asked about their experience using the two different toolsets. The whole procedure lasted approximately an hour.

3.4 Study Design

A 2x2 within-subjects design was employed. The independent variable was the browsing and authoring toolset. They were 'mixed-initiative composition' (combinFormation) and 'typical' (Firefox + Microsoft Word). The order of using the two different toolsets was counterbalanced. Each condition was associated with a different subset of the Buzz; the subset was randomly assigned to the toolset, and these assignments were also counterbalanced.

3.5 Results

We compared empirical logging data between two toolset conditions. For mixed-initiative composition, we counted the entire source URLs associated with media elements they browsed during the task. The results from logging data show that participants were able to browse media from more different web pages using combinFormation than using the typical browser. On average, participants were able to browse 70 pages during the task with Firefox, and they browsed approximately 144 pages with mixed-initiative composition (see Figure 7 left). The difference between the numbers of browsing pages during the tasks was statistically significant [$F(1,6) = -6.071$, $p = 0.002$]. The result indicates that the ResultsDistributor-enhanced mixed-initiative composition lessens users' efforts and time of following links while experiencing popular media. It enhances the diversity of the media they experience.

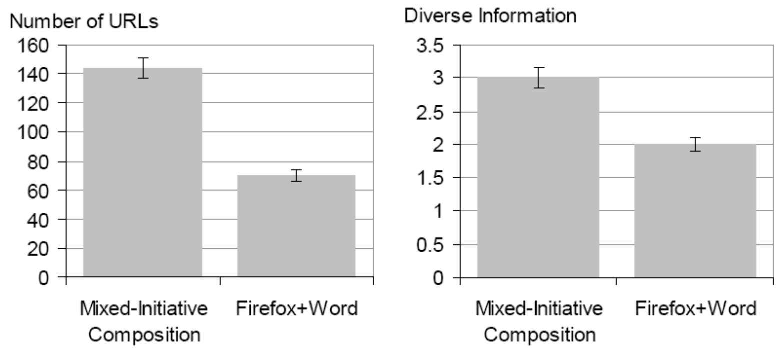

Figure 7. Mixed-Initiative Composition enhances the diversity of media; Left: number of diverse URLs they browsed; Right: Participants' experience ratings about media diversity.

In the intermediate questions, right after each browsing and authoring task, we asked each participant about how diverse was the information that they browsed. The answers were scaled from 1-5. We analyzed their answers, and the average rating score for mixed-initiative composition was 3.0, and that for the typical toolset was 2.0 (see Figure 7 right). With the Paired-Samples T-test, we found that participants sensed that they could browse more diverse information using mixed-initiative composition (combinFormation) than using the typical browser [$F(1,6) = -3.240$, $p = 0.018$]. This user experience result corresponds with the empirical result from logging data, which confirmed the efficacy of the system for browsing diverse information.

In the post questionnaire, we asked participants about their subjective experience of the tools for easy to use, how much they liked it, finding interesting/relevant information, and entertaining (see Figure 8). Four participants answered that mixed-initiative composition was easier to use for browsing and collecting; one said the typical browser and Word, and two said both the same. The participant who selected the typical toolset explained the reason as their unfamiliarity using combinFormation. Participants who chose combinFormation expressed easiness of browsing different and diverse information without the extra work of following links.

> P6: "With the combinFormation technique it allows you to look at topics in relationship to each other and it also gives you information from many different sites. That gives you the ability to see the information on one topic from different points and from sites you may never have found."

> P7: "It was sitting there right in front of you instead of you having to dig and dig for information. Any of the big time things in the world or with pop culture would pop up and it was everything you wanted to know."

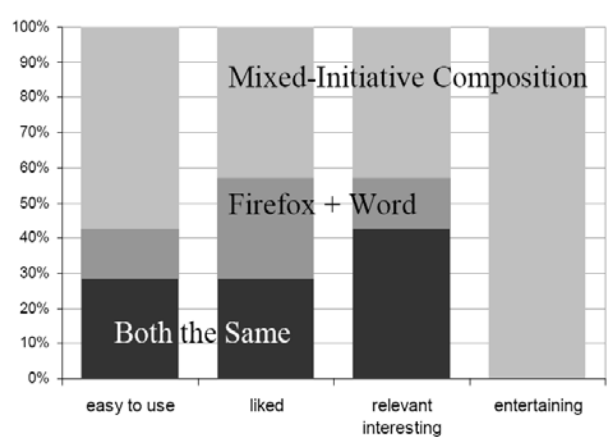

Figure 8. Mixed-initiative composition is easier to use, more liked, finds more relevant and interesting media, and is more entertaining to experience than the typical toolset.

For the question about how much they liked the tools, three participants liked combinFormation better, two liked typical browser and Word, and the rest of two said both the same. Participants who enjoy browsing diverse popular media out in the world liked combinFormation. A couple of participants wanted to focus on specific information, instead of to engage in exploration; they like the control provided by the typical browser.

Then, participants were asked which tool they were able to find more interesting and relevant information while browsing. Three participants answered combinFormation, one said the typical browser, and the rest three said both the same. Participants who found combinFormation useful said image media helped them browse and understand current popular issues. A participant who chose the typical browser said that using the browser they were more able to go directly to the relevant information they wanted.

> P2: "I always think about these… When we browse popular media, I need to see just pictures not the texts… because it is easy to find something using that picture. In that point, combinFormation is easy to browse what I want."

> P1: "combinFormation is very useful to show current issues and just browse"

The last question was which tool was more entertaining. All participants selected combinFormation. They found combinFormation interesting and entertaining because they could look at many different things at the same time more visually.

> P4: "combinFormation is more visual than the browser, it is very interesting"

> P5: "It may help me to find current issues that many people talk about these days. I will surely use it when I want to find a 'something new'."

> P6: "combinFormation was more entertaining because it gave you many things to look at the same time, giving you the ability to choose random topics that you might not think about."

The results showed that combinFormation was more favorable and appealing to participants in the experience of browsing and authoring popular media than the typical toolset. Participants enjoyed browsing visual representations of media extracted from different resources and authoring in a mixed-initiative composition space.

4. BACKGROUND

What users expect in experiencing multimedia is different from that in searching Web. In the area of multimedia searching, Jansen *et al.* noted that multimedia sessions and queries are generally longer than Web searching [11]. Web queries indicate an increased cognitive load for multimedia searching. The research found that multimedia appears to require greater interactivity between the user and search engine, relative to general Web searching [11]. The increase in query and session lengths and the increase in the number of result pages being viewed indicate this greater interactivity. The range of information needs appears to be broadening based on the term level of analysis of AltaVista Multimedia search logging. It showed the frequency of term usage was very low, and also in the multimedia searching with more target term the frequency of top term usage was quite low [11]. Another Web study also reported a trend toward a broadening of information needs [27]. Web users are searching for an increasing variety of multimedia topics.

Humans interact more and explore diverse information more in multimedia searching than in Web searching. The present research develops the ResultDistributor to broaden and diversify the media retrieved, and enhances interactive mechanisms to improve the multimedia experience. Lew *et al.* find that we should focus as much as possible on the user who wants to explore media [16]. It has been known that decision makers need to explore an area to acquire valuable insight, thus experiential systems which stress the exploration aspect are greatly needed.

In searching for a particular media item, current systems have significant limitations, such as an inability to understand a wide user vocabulary and the user's satisfaction level [16]. An important research focus of human-centered computing, with potential for improving multimedia retrieval, is to bridge the semantic gap between computers and human [9]. Experiential computing also focuses on methods for allowing the user to explore and gain insights into media collections [8]. On a fundamental level, the notion of user satisfaction is inherently emotional. Affective computing focuses on understanding the user's emotional state and intelligently reacting to it [22]. It can also beneficial in measuring user satisfaction in the retrieval process.

combinFormation solves the gap between the system and human by developing a human-in-loop interface and algorithm through which the human can interrupt or direct the system's actions throughout the process. The system responds visually. A continuous dialogue between human and the system is formed to achieve personalized media exploration goals. Susanne Boll notes the importance for personalized authoring systems to take the user's context into account [26]. We have developed a media semantics model of the user's interests to support personalized authoring in which the user's interest expressions continuously guide the system agent to bring in elements relevant to the evolving context of the user. In this process, a complex semantic network of elements plays a significant role, preserving the original element context through metadata, while allowing the user to alter it, developing their own specific context of use [21].

People perceive collections through element proximity. People can search and locate their information easily by categorization by means of clustering or classification techniques [14]. Wilcox uses the concept of clustering photos on a timeline to manage photo collections [3]. In our tool, we cluster elements spatially and procedurally based on their semantics.

5. CONCLUSION

Treating information as media, by emphasizing the sensory, enables the aestheticization of browsing-searching-collecting. In combinFormation, the human-in-loop plays an expressive role. The mixed-initiative composition space is the site of media recombination, in which selection and juxtaposition transform the experience of popular media from a passive one, in which content is received, to an active experience of media authoring. Authoring is inherently a creative process. The ability to see media from multiple source contexts at once provides the basis for an aesthetic perspective on navigable space. Being able to see more media, from more diverse sources, provokes the synthesis of relationships. Entertainment value is also increased, even with the demands of functioning as a human-in-loop.

The system evaluation demonstrated the efficacy of combinFormation for browsing and exploring popular media. Using combinFormation, participants could experience diverse popular media and author creative media contents more easily and with a better sense of entertainment than using the typical tools. Since diversity is a measure of creative ideation [4], this indicates that the mixed-initiative composition space promotes a more creative experience.

In addition to Yahoo Buzz, there are many other sources of popular media on the Web. Online communities, such as Flickr and del.icio.us, provide rich channels for interaction and communication among users, in which tagging develops collaborative media semantics. The tags provide a powerful source of popular and interesting media, with descriptive semantics. However in order to access this media, using typical tools, people still need to select and follow links under each tag. By launching combinFormation with a tag as a query and the search engine as one of these online communities, people can browse and collect visual media extracted from tagged URLs in the mixed-initiative composition space.

Popular media experiences are not so different from contexts of information discovery [12] and exploratory search [29]. Developing new ideas, like a thesis or grant proposal topic, is not a linear retrieval process. It requires browsing, surfing diverse spaces of ideas. Each search query formed by a researcher can form a space of relevant source material. The researcher's job is to select the right ingredients, that is, the right searches, feeds, and documents, and develop new relationships, new connections, which become the basis for the emergence of new inventions. The ResultDistributor structure is an important step toward supporting this recombination of the knowledge spaces of searches. The Yahoo Buzz application intensively exercised this capability. Future work will integrate digital library sources, such as CiteSeer, PubMed, and ACM, into combinFormation to provide better exploratory discovery support for research.

As part of the system evaluation, participants gave us suggestions for improving combinFormation. They expressed concern about using combinFormation with a small screen computer, which will limit the number of media elements to browse. Also, they would prefer to see less overlapping of media elements in the composition space. There is still a room for improvement in visualizing large spaces of information. We will explore solutions by experimenting with the integration of multiple coordinated visualization views with the composition space, using techniques such as focus+context [15].

We also plan to support other media format, such as audio and video, in the composition space. By composing multiple media contents in a single space and playing them in the same time, as in the work of Paik [20], the human can compare and experience media, and make this experience a form of authoring. The result will differ from a typical non-linear audio or video editing tool in its emphasis on recombination of existing material. By emphasizing the sensory, developing human-in-loop as expression, integrating search, browsing, and authoring, and supporting exploration, we will develop human-centered experiential new media spaces of navigation.

6. REFERENCES

[1] Baddeley, A.D., Is working memory working?, Quarterly *Journal of Exp Psych*, 44A, 1-31, 1992.

[2] Brin, S., Page, L., The Anatomy of a Large-Scale Hypertextual Web Search Engine, *Computer Networks and ISDN Systems*, 30(1-7),107--117 1998.

[3] Cooper, M.D., Foote, J., Girgensohn, A., Wilcox, L., Temporal event clustering for digital photo collections. TOMCCAP 1(3): 269-288, 2005.

[4] Finke, R., Ward, T., Smith, S.M., Creative Cognition, Cambridge: MIT Press, 1992.

[5] Glenberg, A.M., Langston, W.E., Comprehension of illustrated text: Pictures help to build mental models, *Journal of Memory & Language*, 31(2):129-151, April 1992.

[6] Greasemonkey, http://www.greasespot.net/, last visited 04/13/2007.

[7] Interface Ecology Lab (2006), combinFormation, http://ecologylab.cs.tamu.edu/combinFormation/.

[8] Jain, R., Experiential Computing, Communications of the ACM, 46(7), pp. 48-55, 2003.

[9] Jaimes, A., Sebe, N., Gatica-Perez, D., Human-Centered Computing: A Multimedia Perspective, *Proceedings of ACM Multimedia*, 855-864, 2006.

[10] Jansen, B. J., Mullen, T., Spink, A., Pedersen, J., Automated Gathering of Web Information: An In-Depth Examination of Agents Interacting with Search Engines, *ACM Transactions on Internet Technology*, 6(4), pp. 442-464, 2006.

[11] Jansen, B. J., Spink, A., Pedersen, J., An Analysis of Multimedia Searching on AltaVista, *Proceedings of the ACM SIGMM workshop on Multimedia information retrieval*, 186-192, 2003.

[12] Kerne, A., Koh, E., Dworaczyk, B., Mistrot, M.J., Choi, H., Smith, S.M., Graeber, R, Caruso, D., Webb, A., Hill, R., Albea, J., combinFormation: A Mixed-Initiative System for Representing Collections as Compositions of Image and Text Surrogates, *Proceedings of ACM/IEEE Joint Conference on Digital Libraries 2006*, 11-20.

[13] Kerne, A., Koh, E., Sundaram, V., Mistrot, J.M., Generative semantic clustering in spatial hypertext, *Proc ACM Document Engineering 2005*, Nov 2005, Bristol, UK, 84-93.

[14] Koh, E., Kerne, A., I Keep Collecting, ECDL 2006, 303-314.

[15] Lamping, J., Rao, R., Pirolli, P., A focus+context technique based on hyperbolic geometry for visualizing large hierarchies, *Proceedings of the SIGCHI*, pp. 401-408, 1995.

[16] Lew, M.S., Sebe, N., Djeraba, C., Jain, R., Content-based multimedia information retrieval: State of the art and challenge, *ACM Transactions on Multimedia Computing, Communications, and Applications* 2(1), pp. 1-19, 2006.

[17] Manovich, L., *The Language of New Media*, Cambridge: MIT Press, 1995.

[18] Marchionini, G., Shneiderman, B., Finding facts vs. browsing knowledge in hypertext systems, *Computer* 21(1), 70-79, 1988.

[19] McLuhan, Marshall, Understanding media: the extensions of man, New American Library, NY c1964, 2nd edition.

[20] Nam June Paik Studio, http://www.paikstudios.com/, last visited 04/13/2007.

[21] Ossenbruggen, J., Nack, F., Hardman, L., That Obscure Object of Desire: Multimedia Metadata on the Web, Part 1, *IEEE Multimedia*, 11(4), pp. 38-48, 2004.

[22] Picard, R.W., Affective Computing, MIT Press, 1997.

[23] Pirolli, P., Pitkow, J., Rao, R.. Silk from a Sow's Ear: Extracting Usable Structures from the Web, *Proc SIGCHI 1996*, 118-125.

[24] Rocchio, J. 1971. Relevance feedback in information retrieval, In The Smart Retrieval System-Experiments in Automatic Document Processing, Prentice-Hall, Englewood Cliffs, NJ, 313-323, 1971.

[25] Salton, G., McGill, M.J. 1983. Introduction to Modern Information Retrieval, New York, McGraw-Hill, 1983.

[26] Scherp, A., Boll, S., Context-driven smart authoring of multimedia content with xSMART, *Proceedings of ACM Multimedia*, pp. 802-803, 2005.

[27] Spink, A., Jansen, B.J., Wolfram, D., Saracevic, T., From E-sex to E-commerce: Web Search Changes, IEEE Computer, vol. 35, 107-111, 2002.

[28] Webb, A., The In-Context Slider: Fluid Integration of Interest Expression with Authoring, MS Thesis, Texas A&M University, 2007.

[29] White, R.W., Kules, B., Drucker, S.M., schraefel, m.c., Supporting Exploratory Search, *Communications of the ACM*, 49(4), 2006, 37-39.

[30] Yahoo Buzz, frequently asked questions, http://buzz.yahoo.com/faq/, last visited 03/30/2007.