Developing Generalizable Principles for Objected-Oriented Search Engine Interface Design

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Abstract

The next generation of search engines, vertical search engines, allow web users to search for specific objects on the web, rather than web pages alone. Although object-oriented web searching endows users with unprecedented web navigation power, it also poses a new set of search engine interface design issues. While we understand how to design typical search engines interfaces, we do not equally understand how to design object-oriented search engine interfaces. To help address this problem, we studied the interfaces of eight vertical search engines, and using our findings, derived seven principles for object-oriented search engine design. To illustrate the applicability of these principles, we evaluated the same eight search interfaces with these new principles, and designed interfaces for two object-oriented search engines using the principles we derived.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Theory and methods; H.5.2 [Information Interfaces and Presentation]: User Interfaces—User-centered design;

Keywords: vertical search, object oriented search, search engines, interface design, human-computer interaction, search engine design, design principles

1 Introduction

The advent of the World Wide Web has revolutionized the way we communicate information, and is unprecedented not only in its magnitude but in its disorganization and lack of regulation. Modern search engines help structure the World Wide Web by parsing massive amounts of data to allow search engine users to navigate the web easily. While existing search engines allow users to search the web for web pages, vertical search engines, also known as object oriented search engines, allow users to search for specific objects on the web. Although object-oriented web searching presents users with a new depth of web navigation, it brings with it new problems of interface design.

In the last decade, search engine interface design has had few innovations, largely because the tremendous success of major search engines has set universal standards for typical search engine interface design practices. Compared to ordinary search engine design, we understand vertical search engine interface design to a limited degree, and lack cohesive principles or standards like those of typical search engine design.

Search engines are the mechanism by which users explore, navigate, and understand the web, and vertical search engines present a tremendous advance in this technology, one that grants users unprecedented control over the web. Potentially the next generation of search engines, vertical search engines may usher in a new standard of web navigation, and their interfaces will hold tremendous gravity as their popularity increases. Without a cohesive set of interface design principles as we have for typical web search engines, vertical search engines will be difficult to use by the majority of web users.

To address this problem, we first studied the existing body of work behind search engine interface design, including web design, and specific search engine design principles. Using these principles as a means of analysis, we evaluated the effectiveness of eight, well-known vertical search engines, including apartment, real estate, job, people, and travel search engines, and discussed the strengths and weaknesses of the design of each interface according to existing design principles. Searching for common design problems between the sites, we recorded our evaluation of the eight interfaces against eight existing design principles, noting in particular design issues not specifically addressed by the current principles.

Using our findings from the evaluation of these existing object-oriented search engines and our examination of prior research, we drafted seven principles for vertical search engine design. To demonstrate the applicability of these principles to real-world problems, we used our vertical search engine design principles to evaluate the same eight vertical search engines and draft sample interfaces for two types of vertical search engines.

These principles of interface design will allow further development of our understanding of design principles, and provide a means to improve the functionality of existing vertical search engines.

To present our research, we first introduce the extensive body of work behind interface design, and introduce our methodology. This methodology introduces a bottom-up approach to interface design, which we begin by evaluating eight existing vertical search engines, and to address the common problems of the interfaces, we introduce our seven design principles and put the same eight interfaces to the test against these principles. Likewise we introduce two interfaces that satisfy both the existing design principles and our design principles, demonstrating the value and practicality of our seven design principles.

2 Related Work

2.1 Universal Design Principles

In order to understand the design principles of vertical search engine interfaces, we must first understand the existing body of work, beginning with general design principles. The design process should revolve around the tasks of user, and catered to his or her needs. Specifically, the design process should begin with an analysis of user goals, or the tasks that users need to complete, and continue by outlining success metrics of the interface, namely how the effectiveness of the finished product will be measured [Bailey 2009]. Overall, the design process should focus users and their tasks, and the design of vertical search user interfaces is no exception.

2.2 Search Interface Design Principles

Marti Hearst bridges the gap between universal design principles and search interface design principles by lucidly explaining the

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principles surrounding search interface design in general. Hearst points out that search engines have developed tremendously since their conception. Once available only to the highly educated, search engines have now become a staple for users of all demographics. While search engines once parse only well-maintained, organized databases, modern search engines sift through the world wide web, a network rife with disorganization and unreliable data. Hearst also argues that between 1997 and 2007, search engine design principles have evolved only minimally. This trend is a direct result of the development of simplicity as a fundamental principle in search engine interface design. The rationale behind simplistic interfaces is that searching is a mentally intensive task, and thus any extraneous, unnecessary clutter on the page distracts the user from the exhausting task of browsing through the search results. For typical search engines, Hearst explains that since the group of potential users encompasses the majority of web users, a search engine interface must be appealing to many different types of users, and simplicity is the easiest way to ensure this property [Hearst 2009].

To evaluate the usability of search engine interfaces, Hearst introduces the following set of criteria:

- Learnability - How long does it take the user to learn the interface the first time he or she sees it?
- Efficiency - How long does it take the user to complete their task once they have learned the interface?
- Memorability - How quickly does the user learn the interface once they have learned it, left it for a period of time, and returned to use it?
- Errors - How often does the user make errors using the interface, and how severe are they?
- Satisfaction - How visually pleasing is the interface?

In response to this criteria for evaluating an interface, Hearst introduces a set of design guidelines for search engine interfaces. They are:

- Offer informative feedback of the user's task. Specifically, show the status of the system at all times, allow the user to view results of his or her query immediately, and show how the search engine interpreted their query
- Support user control of the interface.
- Reduce the short-term memory load on the user.
- Provide shortcuts for skilled users to use.
- Reduce the errors of users with simple error handling.
- Be consistent throughout the interface.
- Allow the user to easily reverse his or her actions.
- Design the system for a sense of closure.

In addition to these principles, Hearst introduces the concept of surrogates, the result objects displayed in list form on a search engine that each summarize a result using the key data from that web page, such as the title, description, and URL [Hearst 2009]. This concept of surrogates is critical to vertical search engine design, but Hearst's brief introduction to their design is anything but complete. Although his principles are fundamental and should be followed for vertical search engine design, a more targeted set of principles is necessary for vertical search engine design, and should be used as a layer of refinement on top of these fundamental search engine design principles.

Certain aspects of Hearst's analysis must be reevaluated for vertical search engines. For instance, since object-oriented search engines are catered to a specific object rather than web pages in general, they are more centralized than usual search engines, and have a narrower range of users than do typical search engines. Searching using a vertical search engine is still a mentally exhaustive task, but since vertical search engines entail a narrower set of tasks, the range of potential users for a vertical search engines is narrow and specific compared to typical search engines. Likewise, by the nature of object-oriented search engines, the search task is not necessarily a small step in a user's larger task, but is rather often the task in itself or the majority of the user's larger task. To design the interfaces of vertical search engines, we must consider this change in the scope of the search engine in the user's task.

2.3 Search Engine Interface Design

Building on the research surrounding general interface design and search interface design, Andronico, Buzzi, and Leporini introduce search engine interface design principles by asserting that most search engines cannot change the way in which results are ranked, which poses a problem for many users. For vertical search engines, this problem is particularly relevant, because the specific data types of vertical search engines are typically prone to custom ranking functions. In addition, the authors present the following interfaces components, which they derive from the user-centered design process [Andronico et al. 2004]:

- Arrangement - The arrangement of the page should allow users to rapidly and accurately find the information they are seeking.
- Expressive power - There is a tremendous amount of power in visualizations.
- Number of Elements - Simplistic interfaces, with few, simple elements, allow unskilled or new users to navigate easily.
- Functions - We should be careful in how we present advanced options to the user.
- Clustering - Clustering related data together improves efficiency of the user's task

Although these design principles are far from complete, they lay a solid foundation of design knowledge that we should use for designing vertical search engine interfaces.

Several elite researchers of interface design, including Vaughan, Misha, and Resnick, help lay the foundation for the transition from typical search engine interfaces to vertical search engine interfaces. While typical Internet searches cannot assume any kind of structural consistency of data in the search content, narrower, more specific search tasks can. Thus, the authors argue that search engines be more targeted in what they search to take advantage of this organization of data [Vaughan and Resnick 2006]. Vertical search engines represent just such a development of narrow searching tasks, and this consistency between data on the back end of vertical search engines plays a key role in the interface design through the design of vertical search engine surrogates.

Likewise, author Lieming Huang et al. introduce how we apply some of these principles through their introduction of an adaptive meta search engine interface [Huang et al. 2001]. From the success of their customizable interface, we can see the value of allowing users to control aspects of an interface in search engine interface design.

Finally, from Blackmon et al., we can see the importance of evaluation techniques catered to search engine design and web users.

Specifically, the authors explain that web users navigate pages through the identification of regions and subregions of a web page, hierarchically, until the user finds what they are seeking [Blackmon et al. 2002]. This gives us a model of user behavior to consider when developing our interfaces and illustrates the importance of accurately labeled regions of the page for effective use of our interfaces.

Although this existing body of knowledge of search engine design is thorough and significant, in order to design vertical search engine interfaces effectively, we must obey these principles, but further expand upon them and apply them to the unique challenges presented by vertical search engine interface design, challenges that are absent from typical search engine design.

3 Methodology

We first formulate three, specific research questions, and from these questions, we carefully choose eight representative vertical search engine interfaces to analyze using the existing body of search engine interface design theory.

3.1 Research Questions

Through our research of vertical search engine interfaces, we seek to answer several related but distinct research questions. From these questions, we launch each of our tasks. Our overarching question, *How do we effectively design vertical search engine interfaces?*, can be decomposed into several, more focused research questions.

- How do we develop principles for all vertical search engines, since by nature, each interface differs significantly?
- How do general design principles, web design principles, and search web design principles all fall short of our needs for design principles?
- How do we adapt typical design principles to vertical search engine design, specifically through the design of people search and code snippet search?

3.2 Choosing and Evaluating the Search Engines

Keeping these questions in mind, we picked eight vertical search engines, each pair of which represents two interfaces from a particular niche of web searching, including apartment searching, travel searching, people searching, and job searching. Doing this, we choose a variety of different applications, yet maintain the ability to compare and contrast the two interfaces in each pair of interfaces.

Each pair of search engine interfaces represents two of the highest ranked search engines in each category of web searching according to the Alexa rankings, and thus each pair of search engines represent two of the most heavily trafficked sites in each category of deep web search engines.

To evaluate each site, we considered the existing body of general web design and search engine design principles, and from this analysis, specifically the commonalities between the interfaces and the shortcomings of existing principles for vertical search engines, we outlined eight design principles specific to vertical search engine design.

3.3 Analysis Approach

To analyze the effectiveness of each of the eight interfaces we studied, we kept Hearst's eight principles close at hand, and by these specific principles and the general guidelines introduced by other researchers, we evaluated the eight interfaces and collected the results in a table, shown in Figure 9.

Using the analysis of these interfaces, we took a bottom-up approach, and through a comparison of our findings, we extrapolated seven design principles.

4 Analysis

4.1 Apartment Search Engines

4.1.1 Apartments

Although our primary focus was on the results page of the search engine, we noticed that the homepage, shown in Figure 1a, allows users to visually select a map region to narrow the search area, but also includes extraneous clutter. While the homepage demonstrates good visualizations through the map, the interface is not customizable by the user, and the different functional aspects of the interface are ambiguous and not clearly separated.

To navigate to the search page, users are forced to proceed through several screens narrowing the searching region, but this process provides little feedback to the user's query and is extremely ambiguous. On the other hand, the search results, shown in Figure 1b, are well-representative of the basic information associated with an apartment, but also lack critical information like the number of bedrooms and bathrooms in the apartment, which would have been more useful than the square footage. This results page also contains a notable amount of repetitive information, which resulted in a considerable amount of clutter on the interface.

Comparing this interface with Hearst's design principles, we get a clearer picture of the overall usability of this interface. Specifically, while this interface is visually consistent, specifically in its colors and layout, and allows users to reverse their actions through the use of the browser, it does not provide the users with adequate, immediate feedback to the their queries. The users, rather than immediately seeing this interface's interpretation their query, must move through several intermediate screens before arriving at the actual results.

This interface allows little user interface control, but through its relatively simple interface, reduces the memory load on users in their search tasks. The interface does not provide any readily visible links for advanced users, but does handle errors well.

4.1.2 Cazoodle Apartment Search

Overall, the homepage interface for Cazoodle, shown in Figure 2a, is simple, visually, pleasing, contained simple but relevant data, and allows users to filter by region as did apartments.com.

The results page, shown in Figure 2b, which starkly contrasts that of apartments.com, offers a usable interface for searching, and contains the most critical information, while avoiding any obvious repetition. The site avoids some clutter by allowing users to hide and show interface components via the 'more options' link.

In terms of Hearst's principles, unlike the Apartments.com search engine, Cazoodle Apartment Search provides users with immediate feedback of his or her query, displaying the results immediately to the user. Through its simple interface, it tremendously reduces the memory load of the user, provides shortcuts for advanced users through its 'more options' button, and displays a user-controllable interface component by allowing users to hide and show options.

Cazoodle Apartment search likewise demonstrates simple error handling, consistency in its layout and coloring scheme, reversal

(a)

(b)

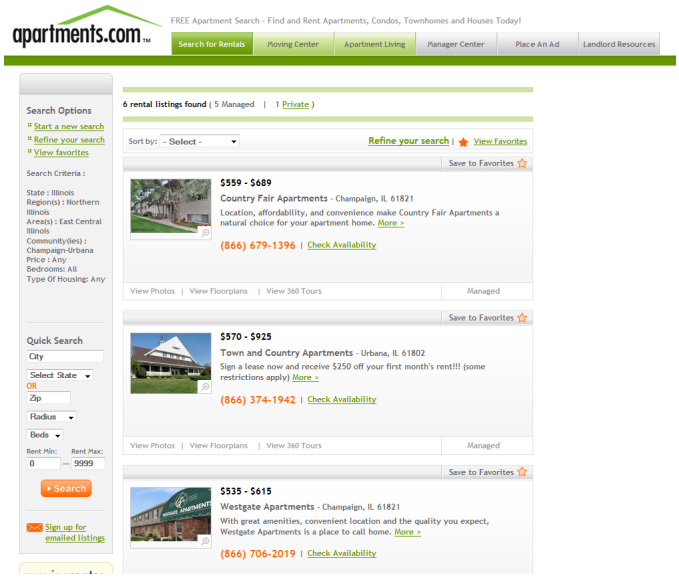


Figure 1: *Screenshots of the home page and results page for Apartments.com, an apartment search engine, taken March 4, 2010 [Apartments.com 2010].*

(a)

(b)

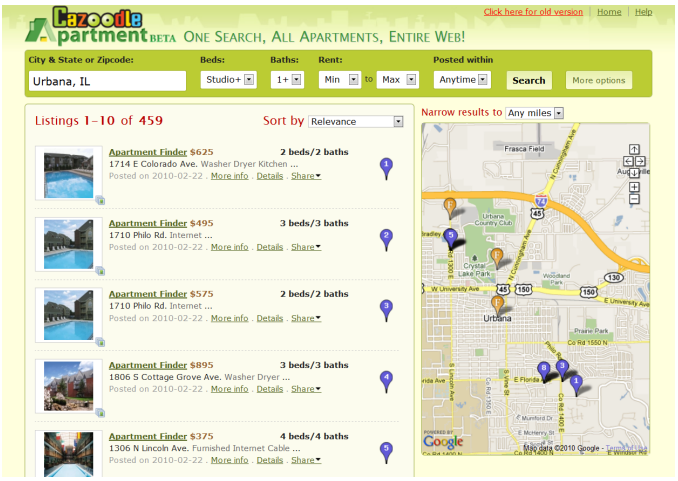


Figure 2: *Screenshots of the home page and results page for Cazoodle Apartment Search, an apartment search engine, taken March 4, 2010 [Cazoodle 2010].*

of user actions through the web browser, and designing for a sense of closure to the user's search.

4.2 Travel Search Engines

4.2.1 Orbitz

Immediately, we noticed several points of interest on Orbitz's homepage, shown in Figure 3a, specifically the extraneous information and links on the bottom and right of the page. Likewise, duplicate and redundant information pervades the interface, resulting in a cluttered, text-filled interface.

Its results page, shown in Figure 3b, boasts a unique display of search results through its innovative MATRIX display, but includes redundant result information. Although this MATRIX design is innovative, it is inconsistent with the rest of the page, and thus the search results are not clearly defined, much less presented coherently to the user. This lack of consistency likewise translates to repetitive options, and an awkward organization of the page. Although there are some meager attempts made to aid the user's flight purchase and vacation planning process, these attempts could be drastically improved by overhauling the interface.

By Hearst's principles, Orbitz does not provide clear feedback to the user's query, because it never explicitly displays its interpretation of the query. The interface does allow some user control of the interface through the 'expand search options' link, but its complex design certainly does not reduce the short-term memory load of the user.

On the other hand, the interface does provide shortcuts for advanced users, simple error handling, consistent coloring and layout schemes, reversal of user's actions, and a sense of closure to the user's task.

4.2.2 Bing Travel

Bing's Travel homepage, shown in Figure 4a, unlike Orbitz, is easily navigable due to its relative simplicity. There is little repeated data, and the interface is more clearly organized than that of Orbitz.

Further, on the results page, shown in Figure 4b, we observe that the page is well-spaced and clearly separated into regions, making it surprisingly more navigable and usable than Orbitz. Likewise, the search results are well-designed and succinctly represent each travel option.

Likewise, Bing Travel demonstrates each of Hearst's principles, to some degree. Through the clear, immediate display of Bing's interpretation of the user's query, the interface provides useful, immediate feedback for the user, and the numerous hide and show options near the left provide the user with a degree of control over the interface.

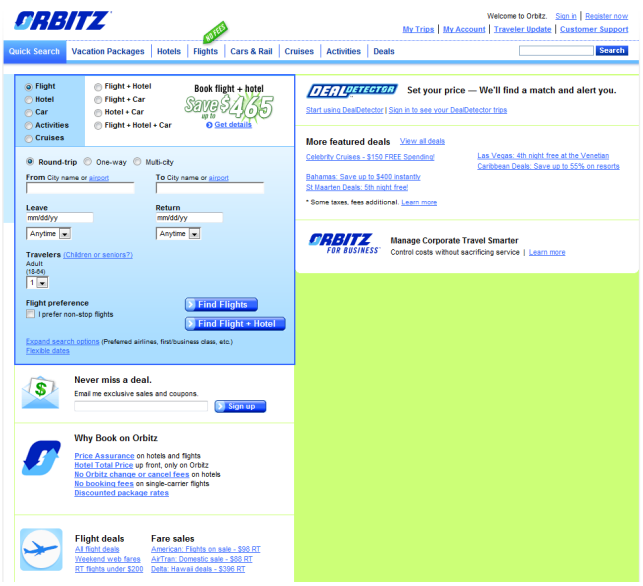
The simple presentation of results, despite the large amount of data displayed, aims to reduce the short-term memory load of the user. Likewise, the interface provides shortcuts for advanced users throughout the screen, handles simple errors, demonstrates excellent visual consistency, allows users to reverse their search process, and designs for a sense of closure, just as Hearst suggests.

4.3 People Search Engines

4.3.1 White Pages

Examining the homepage of the White Pages, shown in Figure 5a, we immediately notice the consistent, pleasing coloring scheme

(a)



(b)

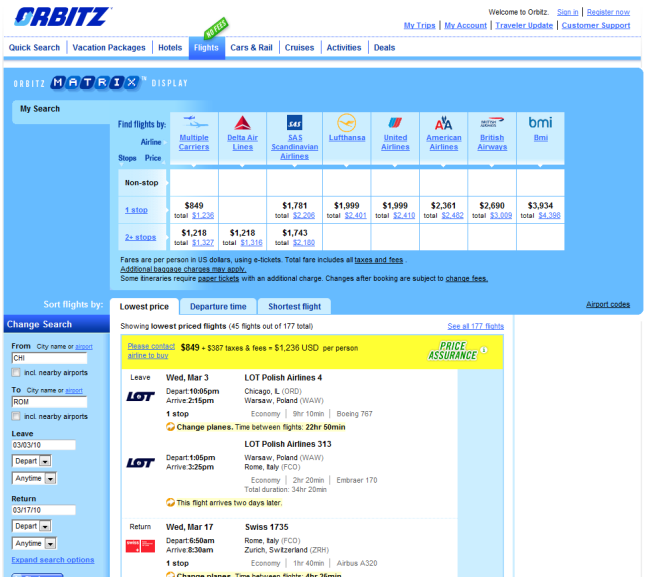
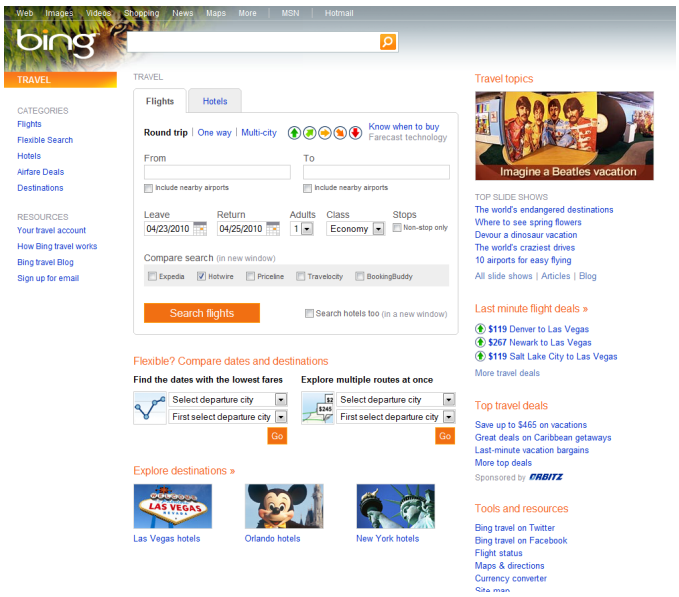


Figure 3: *Screenshots of the home page and results page for Orbitz, a travel search engine, taken March 4, 2010 [Orbitz 2010].*

(a)



(b)

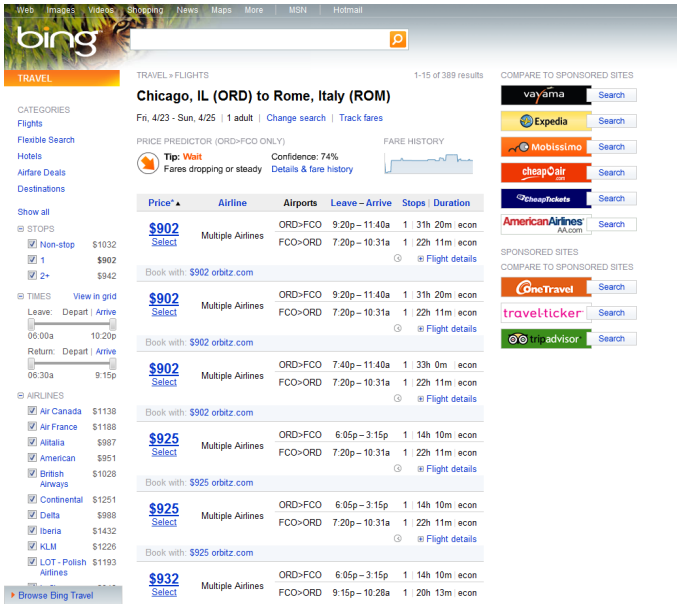


Figure 4: *Screenshots of the home page and results page for Bing Travel, a new travel search engine by Microsoft, taken March 4, 2010 [Bing 2010].*

and simple design. Although people search engines have tremendous capability for visualizations, the homepage is extremely text-oriented, increasing the cognitive load of the user. Although there is little repetition, the various components of the interface are randomly distributed throughout the page, rather than being unambiguously separated.

The results page, pictured in Figure 5b, demonstrates a similar set of pros and cons. On one hand, the interface exemplifies a very simple design for people searching, and the map helps the user visually narrow people results. However, considering the large amount of visualizations capable with objects like people, the interface could have used more visualizations to ease the user's task.

Evaluated against Hearst's principles, the site's interfaces succeeds in five categories, and fails in the other three. Because the site does not clearly present that name was actually queried, it does not provide useful feedback to the user as Hearst suggests, and does not allow users to control any aspect of the interface.

While the interface does not provide any notable shortcuts for advanced users, it does provide a simple, consistent, error-resilient interface. Likewise, the interface demonstrates a sense of closure and allows users to reverse their actions when necessary.

4.3.2 ZabaSearch

Examining the homepage for ZabaSearch, illustrated in Figure 6a, we observe that there is little color, a disarray of text, and a complete lack of visual components to the interface. The options were repetitive and disorganized, posing significant usability problems to the user.

The results page, structured similarly to the homepage, presents a more clear separation of functionality through the separation of sponsored and unsponsored results. However, the interface presents a once again cluttered display, with ambiguously labeled links, no visualizations, inadequate surrogates, and repetition.

Held to the standards of Hearst's eight principles, ZabaSearch obeys five of the eight principles, and does not obey the other three. On one hand, the interface does not clearly display how it interpreted the user's query, allow user control of the interface, or provide a light cognitive load for the user.

Rather, the interface is extremely text-heavy, providing countless shortcuts for advanced users, error handling mechanisms, and a means reversal of user's actions. Likewise, the interface, although extremely cluttered, demonstrates good consistency in its layout and coloring, and designs for a sense of closure to the user's people searching task.

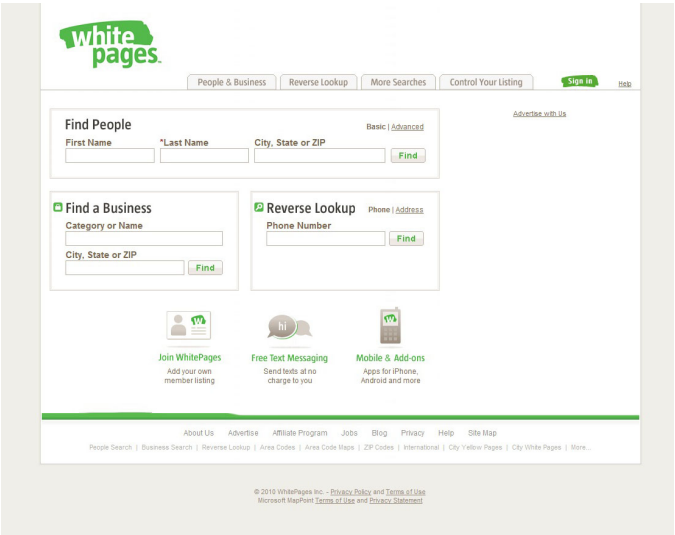
4.4 Job Search Engines

4.4.1 SimplyHired

Examining the SimplyHired homepage, shown in Figure 7a, we see the simplicity of this interface, in that there are only two text boxes, clearly displayed, with which to search. However, the simplicity of the text boxes are ruined by the lack of examples of how, specifically, they are intended to be used.

The results page, shown in Figure 7b, is too wide for narrow computer screens, does not show feedback of user activity, and has some ambiguous buttons and links. Likewise, and very importantly, the interface ignores any visual components to job searching, such as maps of job locations, and graphs of market trends and industry salaries.

(a)



(b)

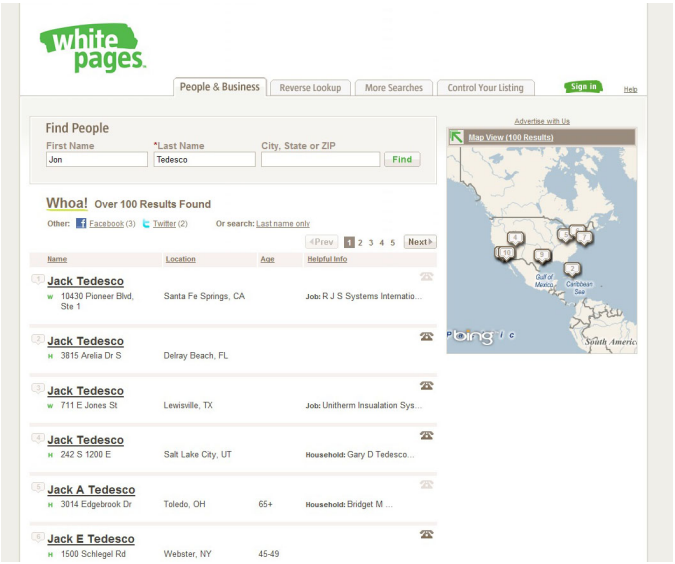


Figure 5: *Screenshots of the home page and results page for the White Pages, a popular people searching site, taken on March 4, 2010 [White Pages 2010].*

(a)

(b)

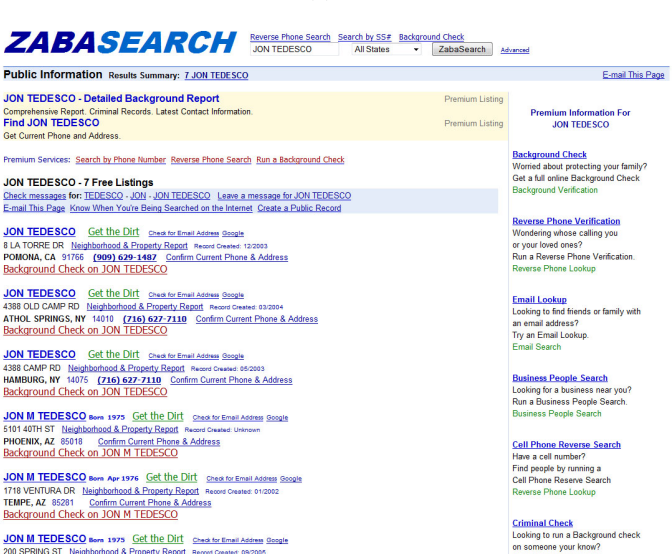
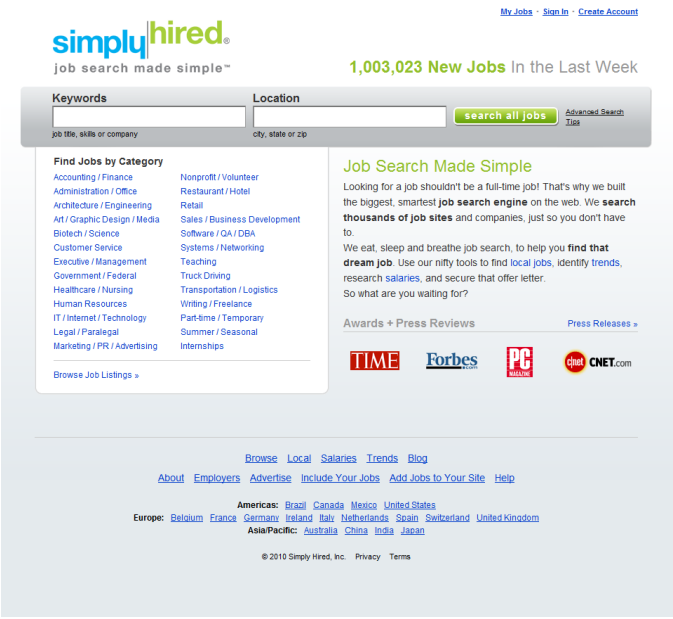


Figure 6: *Screenshots of the home page and results page for the Zaba, a people search engine, taken on March 4, 2010 [Zaba 2010].*

(a)



(b)

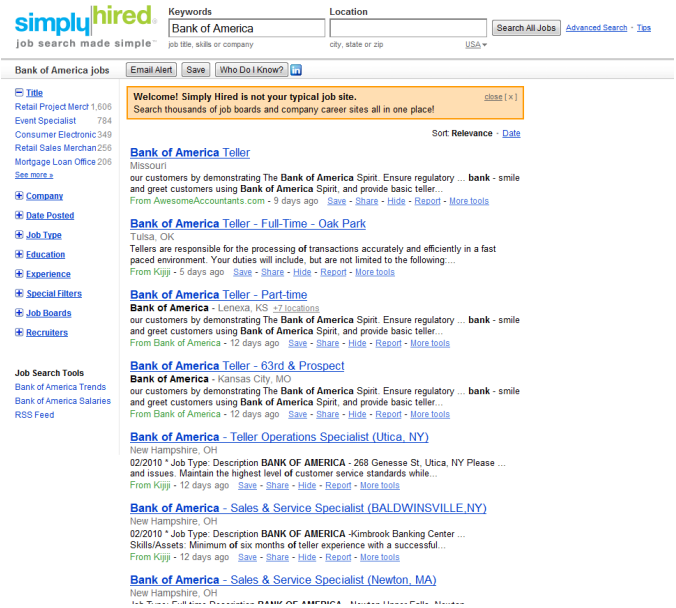


Figure 7: *Screenshots of the home page and results page for the SimplyHired, a popular job search engine, taken on March 4, 2010 [SimplyHired 2010].*

Just as did Cazoodle Apartment Search, the interface of SimplyHired obeys all of Hearst's design principles. Through the upper-left display of the interpretation of the user's query, the interface provides the user with adequate feedback, and through hide and show options on the left, allows user control of the interface.

Likewise, the simple presentation of the large amount of data from SimplyHired demonstrates the interface's aim to reduce the cognitive load of the user, and the links in the bottom left provide options for advanced users. The interface also provides error handling, demonstrates a consistent layout, allows users to reverse their search process, and designs for a sense of closure to the user's job search.

4.5 Real Estate Search Engines

4.5.1 Zillow

On the Zillow homepage, shown in Figure 8a, we observe that although there is once again only one primary text box, the interface nonetheless remained extremely cluttered by extraneous data. Interestingly, the interface includes no sample queries and approaches the user's tasks by addressing as many as possible, rather than prioritizing and focusing on a few, primary ones.

On the results page, shown in Figure 8b, the interface was likewise crowded with an excess of repetitive options and results, advertisements intermingled with actual results, and essentially an oversaturation of information. In fact, due to the tremendous amount of excess data, the main portion of the results are not visible without scrolling down.

Through the categorization near the top left of the screen, the interface demonstrates Hearst's principle of providing feedback to the user. However, the interface does not allow any noticeable user control or attempt to reduce the memory load of users. Although the map is a good attempt at a visualization of the search results, its presentation renders it more of an illustration than a search tool. Overall, although Zillow has good rudimentary considerations of the user search tasks, it poorly presents them, and thus renders its efforts in vain. On the other hand, the site designs the interface towards the closure of the user's goal to buy a home, enables users to reverse the search process, provides a consistent design, handles simple errors, and through the numerous extraneous links and options, the interface provides links for advanced users.

4.6 Analysis Summary

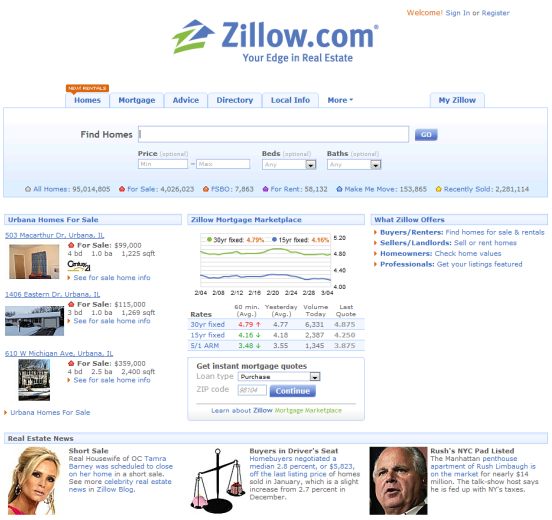
To summarize our analysis of the existing vertical search engine interfaces we studied, we created a table, shown in Figure 9, which summarizes our findings. Although some of the interfaces did not satisfy the basic design principles outlined by Hearst, all satisfied at least half of these eight essential design principles, and half of the design principles were satisfied by all eight interfaces.

5 Design Principles

Using our analysis of existing vertical search engine interfaces, we drafted a list of seven fundamental principles that we learned, none of which was directly addressed through general design principles, but all of which incorporated and supported existing design principles. For each principle, we first introduce the principle we developed and describe it in detail. Next, we address the background of each in both our findings and the existing body of interface design principles.

Essentially, our seven design principles boil down to the following:

(a)



(b)

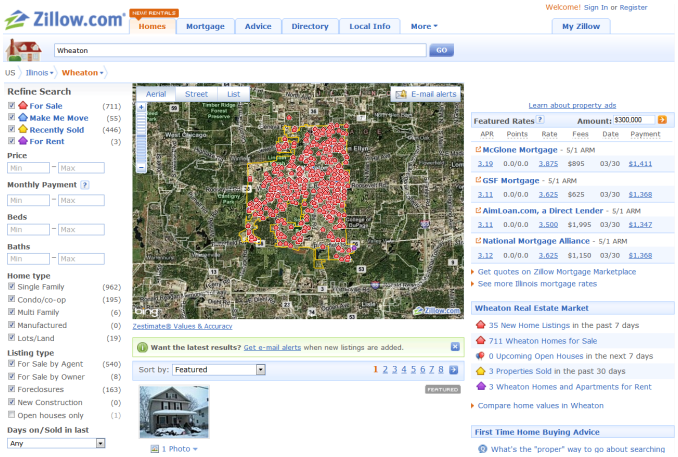


Figure 8: *Screenshots of the home page and results page for the Zillow, a real estate search engine, taken on March 4, 2010 [Zillow 2010].*

	User Feedback	User Control	Reduced Mental Load	Advanced Shortcuts	Error Handling	Consistency	Reversability	Sense of Closure
Apartments			✓		✓	✓	✓	✓
Cazoodle	✓	✓	✓	✓	✓	✓	✓	✓
Orbitz		✓		✓	✓	✓	✓	✓
Bing Travel	✓	✓	✓	✓	✓	✓	✓	✓
White Pages			✓		✓	✓	✓	✓
ZabaSearch				✓	✓	✓	✓	✓
SimplyHired	✓	✓	✓	✓	✓	✓	✓	✓
Zilow	✓			✓	✓	✓	✓	✓

Figure 9: *Table summarizing our findings from analyzing the eight existing vertical search engines we chose to examine. Each row shows an interface, and each column holds several keywords indicating one of Hearst's eight principles.*

- Include Visual Cues Catered to the Interface Application
- Incorporate Visual Filtering Mechanisms
- Carefully Construct and Customize Result Surrogates for the User's Task
- Avoid Repetitive Information and User Options
- Consider the Context of Web Searching in the Users Overall Task, and Give Feedback to Users Larger Task
- Distinguish Functionality by Subtasks or Potential Tasks of the User
- Allow Users to Hide and Show Options

Throughout our development of these principles we rely on the knowledge that vertical search engines have more specific knowledge of their user base than do ordinary search engines. For example, while a typical web search engine must be usable for all web users, since a vertical search engine has a narrow user base, a vertical search engine interface is must focus on being usable to a more targeted people group.

For example, according to Alexa.com, the website information company, code snippet search engine users are typically more highly education than average, primarily male with graduate school experience. On the other hand, people search engines are more frequently used by women than men, and are used primarily by graduates of only high school [Alexa 2010].

5.1 Include Visual Cues Catered to the Interface Application

When drafting the interface of a particular vertical search engine, we should consider the specific task of the vertical search portion of the user's task, and include visualizations to facilitate using the interface, visualizations that are specific to the particular type of search engine.

As we know from existing design principles, visualizations are a powerful mechanisms to use to convey information to the user. In the design of vertical search engine interfaces, there is no exception to this rule. In fact, this is even more true for vertical search engine interfaces, which typically have a variety of unique visualization opportunities to seize. Unlike typical web search engines, which focus on web pages exclusively and are typically text-centered searching mechanisms, vertical searching tasks, since they revolve around real-world objects, often take advantage of creative and intuitive visualizations to aid the user's task.

This principle was derived from the lack of many visualization techniques that could have been utilized in existing vertical search engines. However, several sites likewise utilized visualizations creatively and effectively, easing the usability of the interface.

As an illustration of this principle, consider the interfaces of Cazoodle and Orbitz, shown in Figures 2 and 3, respectively. For example, Orbitz visualizes data about each flight by displaying the company logos of flight companies for each flight, visually cuing users to information about each flight. Likewise, Cazoodle visualizes each apartment using pictures of the property and color coding results, categorizing them into the sponsored and unsponsored results to aid the user.

Since this principle likewise aims to ease the user's task, it further extends the importance and applicability of the principle of the interface designer to ease the short-term memory load of the user.

5.2 Incorporate Visual Filtering Mechanisms

To further enhance the usability of the interface, we should visualize the options for filtering results as much as possible. Although the concept of filtering is addressed in the existing body of work of search engine interfaces, no existing work specifically addresses the importance of visualizing those filtering options as much as possible.

Just as with the previous design principle, much of the basis of this principle is derived from the significance of visualizations in interface design, but this principle is also derived from the commonalities we found throughout existing search engines to allow application-specific filtering mechanisms. The most usable interfaces often included a visualization mechanisms, uniquely designed for the user's task.

For instance, search engines such as Apartments.com and Cazoodle, shown in Figures 1 and 2, respectively, incorporate mechanisms to filter the apartment search results by region and city. However, while Cazoodle allows users to narrow results visually using a United States map divided in regions, Apartments.com offers the same functionality, but nearly entirely text based, which impedes the interface's ease of use, dramatically increases the memory load of the user, and slows their task completion time.

While this incorporates the existing design principles of visualization, it further extends and applies these principles to visual filtering techniques. While filtering techniques already exist for typical web searching and vertical web searching, as aforementioned, vertical web searching enables a new degree of visualization, and thus we can visualize and add greater functionality to the filtering mechanisms of vertical search engines than we can for typical web search engines.

5.3 Carefully Construct and Customize Result Surrogates for the User's Task

Result surrogates are the individual entries in the list of results of a search engine, each of which represents an entry in a large list of results. For typical web search engine design, surrogate design is simple compared to vertical search engine surrogate design, in that the surrogate design for ordinary web searching entails one, specific list of components that are to be included, while the components of vertical search engine surrogates depend on the individual vertical search engine.

Since typical search engines search through web pages alone, the only object data we must represent through the surrogate is that of a web page. However, for vertical search engine design, we must consider the specific object that we are searching for, and design the specific surrogates, a task already taken for granted in the well-explored area of typical web search engine interface design.

While this gives the interface designer a new degree of freedom, it likewise lays the responsibility of determining the key object data of a vertical search engine results on the shoulders of the designer, along with the responsibility for prioritizing that data to compose well-structured, succinct but adequately detailed object surrogates.

As interface designers, we must cater the object surrogate to the specific type of vertical search engine we are considering. While these surrogates must contain all relevant data to the object, the data included must be prioritized carefully, so as to strike a balance between fully informative but cognitively overwhelming to the user, and easily understandable to the user but uninformative.

To illustrate this principle in action, consider the interfaces for Bing Travel and Orbitz, show in Figures 4 and 3, respectively. While Bing displays informative result surrogates, surrogates that include data such as the the airlines, price, airports, times, stops, duration, class, and even shortcuts to book the flight, it does so cleanly, hiding the flight details behind a link near the bottom of each surrogate, and prioritizing and neatly organizing the data into a readable list.

On the other hand, Orbitz displays neither the same magnitude not quality of result surrogates. The surrogates shown in the Orbitz interface are all crammed near the bottom, hardly separated from each other at all. Likewise, they lack the same thorough content of data and readability that Bing's surrogates illustrate.

This principle builds on the existing principles of search engine surrogates and user-centered design, because it incorporates designing search result surrogates directly catered to the needs of the user and specific application. This holds the user goals as the central focus of interface design, while addressing the concerns with current systems of design theory.

5.4 Avoid Repetitive Information and User Options

This principle focuses around cluttering search user interfaces. As we have learned in previous interface design research, we should strive to simplify interfaces while making the user's task as easy as possible. However, despite this focus, we found many vertical search engines disregarding this principle, but in a more specific aspect than previously discussed. Specifically, many interfaces we studied had duplicate links to equivalent or nearly equivalent user tasks or displayed repetitive information to the user. While this allows the user two paths to complete his or her task, it can also be confusing to the user because of the seemingly duplicate option. Likewise, it undoubtedly clutters the interface, and could even belie a more serious underlying design problem.

For example, the interface of Orbitz, shown in Figure 3, demonstrates some repetitive options and data in that for each flight option, we see the price, number of stops, and carrier displayed twice, once in the results list near the bottom of the page, and once in the MATRIX display near the top of the screen. Although this was clearly done in an effort to coordinate the results list and MATRIX display, it considerably clutters the interface with duplicate data.

Although this is similar to existing principles of interface design, this is of particular importance to vertical search engine interface design because vertical search engines, by nature, support a variety of user tasks and application-specific data. Thus, the interface is easily cluttered, and what would be an easy and valid option for typical search user interfaces translates to a costly and ineffective solution for vertical search engine interface design.

5.5 Consider the Context of Web Searching in the User's Overall Task, and Give Feedback to User's Larger Task

For typical web searching, the actual search task comprises only a small portion of the user's actual task. As a result, standard search engines are designed to facilitate speed and ease of use, essentially minimizing the role that the search engine plays in the user's task. However, for vertical web searching, the scope of the search task is highly variable. For instance, although specific vertical searching tasks may comprise a small fraction of the user's task, others, such as those of a shopping-oriented search engine, embody a larger portion of the user's task. In fact, oftentimes, the search engine plays the primary role in the user's task. Since this is highly variable, and certainly drastically different than typical search engine interface design, this is a critical principle that we must realize for vertical search engine interface design.

While some franchises and specific vertical search engines, such as Bing Travel, understand this altered role well, most existing search engines ignore this drastic role change of the searching task. Bing's interface, displayed in Figure 4, illustrated a serious consideration of the user's larger task by including information not only about specific flights, but also providing feedback to the user's vacation plan in general. Above the results, the interface displays a fare prediction, which tells the user whether now is the best time to travel, using the 'tip' indicator. To support its feedback, it provides the user with a confidence rating, fare history report, and predicts future behavior of ticket prices. Thus, Bing reports the search results, but also gives feedback to the user's travel plans in general, a perfect example of considering the overarching task of the user, in this case, planning a vacation.

This principle supports the concept of user-centered design, specifically placing the focus of our design process on the user's task, even outside the scope of the actual search engine task. Since there are likely several tasks that a vertical search engine user may have, we must carefully separate them into different regions of the page. However, this is the idea to which we refer in the next design principle; rather, this design principle asserts that it is important to simply consider and address the multifaceted tasks of the user.

5.6 Distinguish Functionality by Subtasks or Potential Tasks of the User

While the previous principle asserts that vertical search engines play an altered role in the user's task, this principle embodies clearly organizing the search interface by unambiguously separating the physical space of the page into regions and subregions, according to the task associated with components of the page. As we have learned through the cognitive walkthrough interface evaluation technique, specifically through cognitive walkthrough for the web, users navigate web pages by scanning the organization of the page, specifically the headers of regions and subregions of pages, and choose specific region or subregions based on their interpretation of the region's applicability to their task.

In the vertical search engine interfaces we critiqued, we observed that many of the interfaces had layouts whose regions had ambiguous purposes, typically due to trying to support a variety of user tasks. According to cognitive walkthrough for the web, this ambiguity translates the reduced interface usability.

A perfect illustration of not clearly separating possible user tasks can be found in the interface for the ZabaSearch, a people search engine shown in Figure 6. While the site includes links for numerous possible tasks of the user, including searching for email address, looking through property reports, and running a background check, it does not clearly separate each task. Rather than being clearly moved to different portions of the page, and spacing them out clearly, the interface lists them altogether.

For vertical search engine interfaces, this organization is particularly important, because the user's search tasks often involve a higher level of detail than the tasks for typical web searching. A vertical search engine, unlike a typical web search engine, may need to provide support for several, distinct user tasks or subtasks, and thus this layout organization is key to maintaining the usability of the interface.

5.7 Allow Users to Hide and Show Options

As developed in previous interface design studies, the user's ability to control the interface and change it on-the-fly is indicative of its success. However, although this principle is highly applicable to vertical search engine design, it has been largely overlooked in vertical search engine design. Specifically, for vertical searching, we have the capability to allow users to hide and show different aspects of the interface, particularly filtering options, both collectively and individually.

Many of the interfaces we studies lacked this ability, but some, such as SimplyHired, shown in Figure 7, implemented them extraordinarily well, by allowing users to hide and show each category of options, while still enabling advanced users the power of all filtering options available.

This builds on the existing body of design research in that it allows shortcuts for advanced users of the interface and allows user control of the interface. Although this principle is deeply rooted in existing design principles it is particularly important for vertical web searching, where a plethora of filtering and searching options may be necessary, depending on the particular object being processed. Thus, as a general rule, we should exercise allowing the user to dynamically hide and show interface components. To address this principle in our interfaces, we allowed users to hide and shows filtering options, both individually and collectively.

6 Application

Next, we evaluate the same eight vertical search engines as before, and compare their performance against our principles with their performance against Hearst's principles. Furthering the development of these principles, we introduce two interfaces of our own that satisfy both sets of principles.

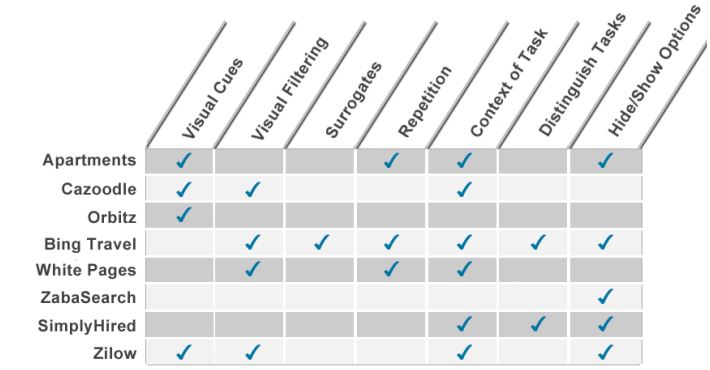
6.1 Re-Evaluating the Old Interfaces with the New Principles

Using the existing body of search engine interface design principles, we evaluated eight search engine interfaces and from our findings, we were able to extract several high-level design principles applicable to the design of all vertical search user interfaces. To illustrate the value of these principles, we first evaluated the eight interfaces from before, but this time by both Hearst's design principles and ours. The summarized results of this second analysis can be seen in Figure 10. Figure 10a is equivalent to Figure 9a, as presented before, but Figure 10b shows the evaluation of each interface by our new design principles. Interestingly, the eight interfaces satisfy our principles much less thoroughly than they do Hearst's original design principles.

When evaluated with our principles, although Apartments.com, shown in Figure 1, gives visual cues to the user, such as the favorites icons, dollar signs, special fonts, and photographs in the results, it also lacks any mechanism to visually filter results. Likewise, the result surrogates include headlines from the advertisers, but not the number of bedrooms or bathrooms, or even the relative locations of the results. While there is no noticeable repetition of data, tasks of the user are clearly separated, and those tasks consider the potential tasks and context of the search engine well, the site offers no ability for users to hide and show filtering options.

Cazoodle's result surrogates, shown in Figure 2, unlike those of Apartments.com, include the critical information that was missing from Apartments.com, such as the location, bedrooms and bathrooms, but also include ambiguous or unnecessary items, often repetitive, such as the 'details,' 'more info,' and 'share' links. On the other hand, Cazoodle offers excellent visual cues for the user, similar to Apartments.com, but to a further extent. The map also acts a visual filtering mechanism, by which users can narrow results by proximity, to either a certain location or to other results.

(a)



(b)

Figure 10: *Table summarizing our findings from analyzing the eight existing vertical search engines, this time against both sets of principles. As before, each row shows an interface, and each column holds several keywords indicating one of Hearst's eight principles.*

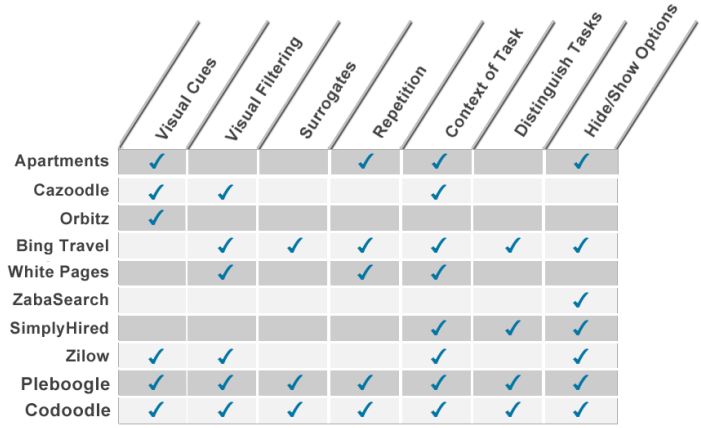


Figure 11: *This table juxtaposes our interfaces with the eight existing interfaces, evaluated using both sets of principles.*

While Cazoodle separates the functionality well, it does not consider the context of the user's search completely, but does allow the user some interface control by allowing users to hide and show the detailed options arbitrarily using the 'more options' button.

For Orbitz, shown in Figure 3, we noted that although the interface gives the user many visual cues through logos and symbols, it lacks a mechanism to visually filter the results, and such a design is certainly possible here, perhaps using a timeline or other time-based illustration. Likewise, the result surrogates are difficult to locate or read incomplete, and repetitive options pervade the interface. While the interface provides some basic consideration of the user's overall task, it does so to a minimal degree, allows no user control of the interface, and does not separate different functionalities clearly.

For Bing's interface, illustrated in Figure 4, we noticed that Bing omitted the majority of potential visual cues to the user, aside from the company logos near the right. However, it uses a timeline mechanism on the left to visually narrow search results, carefully organizes the surrogate data, demonstrates little or no repetition, allows users to hide and show portions of the options, and even provides fare history and prediction to assist the user's overall task of planning a vacation.

In WhitePages's interface, pictured in Figure 5, we note that it provides few visual cues to aid the user, minimal data in the result surrogates, does not allow users to alter the interface in any way, and omits most data or functionality that would assist the user's overall task. On the other hand, the map allows users to visually narrow people results by general location, there is little repetition, and the functional components of the interface are clearly separated and unambiguous.

ZabaSearch's interface, shown in Figure 6, provides the user with a plethora of links for possible tasks, but does not clearly separate and organize them into regions of the page. The interface also gives no visual cues or visual filtering mechanisms to the user, displays overcrowded, confusing result surrogates, and displays much duplicate data.

SimplyHired's interface, pictured in Figure 7, while providing functional components specific to the user's task and clearly organized them into regions of the page, also excludes most visual cues for the user and all visual filtering mechanisms. Likewise, the result surrogates are overcrowded with largely unhelpful job description snippets and repetitive duplicate results.

In evaluating Zillow's interface, included in Figure 8, we see that Zillow uses countless visual cues to aid the user, and allows users to visually filter results through the map in the center of the page. Likewise, the interface provides a plethora of functionalities to users, and separates them clearly into different regions of the page. However, the interface also lacks any user-controlled interface components, displays no useful result surrogates, and gives excessive repetition, particularly in the statistics of the results.

6.2 Evaluating the New Interfaces with the New Principles

To demonstrate the principle of including visual cues in our interfaces, in the people search engine interface that we drafted, we take advantage of people-specific visualizations, such as avatars of the person's face, color coding of the male and female filtering options, and logos for social networking sites associated with each person's profile. For the code snippet search engine, although this interfaces is centered around a much more text-oriented content type, we are nonetheless able to include visual cues to guide the user. To aid users, we include syntax highlighting in the code snippets to visually cue users towards keywords throughout the results. Likewise, we include color-coded bits of information throughout each surrogate such as the language of the result, line numbering, and the specific search terms in the code snippets.

To demonstrate how to incorporate visual filtering mechanisms into vertical search engines, in our people search interface, we include a map-based system that allows users to visually narrow the results list by region. We allow the users to filter by gender and age using a color-coded timeline, rather than a large amount of text. In our code snippet search engine, we incorporate this same visual filtering principle by color-coding the important data of results, and visually representing the counts of code snippets of each language that received hits.

To demonstrate carefully planned result surrogates in our interface designs, we show key information for both people and code snippet objects, considering primarily the needs of users and desired information. Specifically, in our code snippet search engine, we include information about the file, language, and source of each code snippet, along with syntactically-highlighted portions of the code, numbered by line. For our people search engine interface, we indicate key information such as each person's name, age, and contact information. Likewise, we show their relative geographic locations using a map, and provide a link to show more detailed results information, including social networking sites and web site results.

To avoid repetitive user options with our interface designs, we carefully place each interface option, so as to avoid any need for repeated options. To preserved simplicity, we pursue a single means to user tasks, rather than duplicate ones, thus avoiding repetitive user options and data.

In our interfaces, to demonstrate how to separate different tasks of the user, we ensure a distinct separation between physical regions of the page and their individual purposes. For instance, in both interfaces, we have a filtering section, querying section, results list section, and miscellaneous information section, the latter typically containing copyright information and company information.

To consider the context of the search engine in the users' overall tasks, we added links that might be useful to users of our interface, in the context of their larger search task. In our code snippet search engine, we provide a link to the man pages, a valuable resource for many programmers, that may be used in conjunction with our search engine. Likewise, the filtering options we provide are catered to the user's anticipated overarching tasks. For the people search engine, we include contact information with the consideration that users of our interface would likely be seeking to contact a particular person.

Finally, to allow users to hide and show options, in the people search engine interface, we allowed experienced users to hide and show the more advanced options and 'more info' for each result. In our code snippet search engine interface, we allow users to hide and show the options as a whole, or hide and show the details of any one particular filtering option.

7 Conclusions and Future Work

Vertical search engines represent a new, imperative web technology, but their success will be marred by our minimal understand of their interface design unless we pursue research in this area. Although we have cohesive, universal principles for typical web search engine interface design, we lack a similar set of general principles for vertical search engine interface design. Our work, derived from existing vertical search interfaces and an examination of related literature, supports and builds on existing design principles and presents

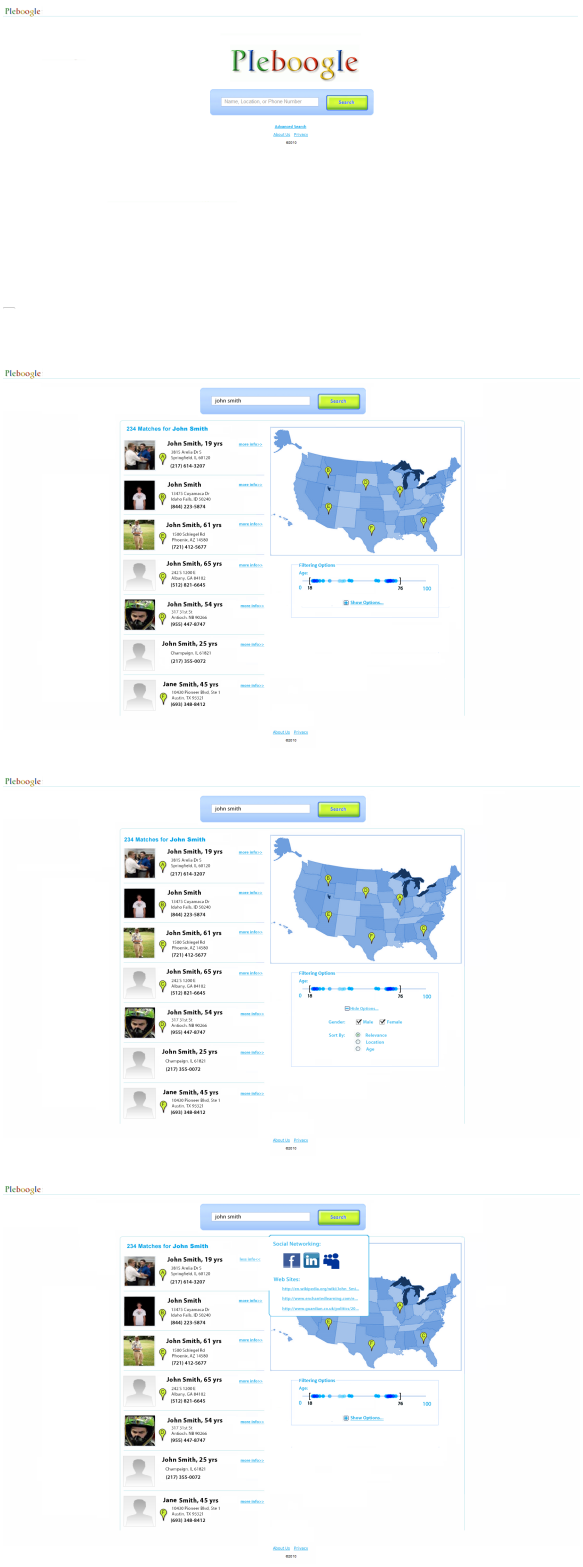


Figure 12: *This figure represents several different possible screens of our own people search engine interface, named Pleboogle.*

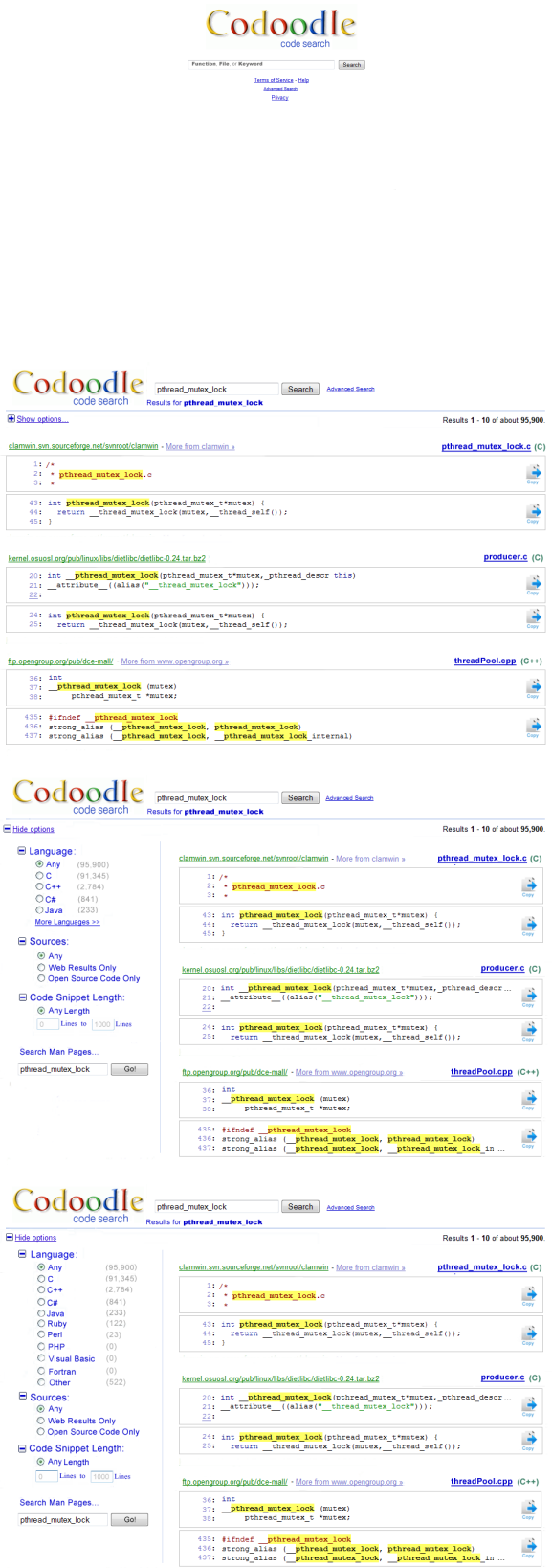


Figure 13: *This figure represents several different possible screens of our own code snippet search engine interface, dubbed Codoodle.*

a generalized set of design principles, useful for vertical search engines, that helps develop our understanding of this problem in the body of search engine interface design knowledge. These general design principles represent a newly developing area of interface design and open it to further research, while presenting immediate potential benefits to existing object-oriented search engines.

To derive our seven design principles, we first evaluated eight existing vertical search engine interfaces using eight existing design principles, and from the theory behind those principles and the results of our interface analysis, we drafted our own seven design principles. To demonstrate the validity and practicality of these design principles, we then evaluated the same eight vertical search engine interfaces using our seven design principles, and drafted two interfaces that satisfy both the existing set of principles and our set of principles.

In the future, we hope to demonstrate the efficacy of these design principles through usability testing of our own, contrived interfaces. Specifically, we hope to affirm the effectiveness of these design lessons through user evaluation of the people search engine and the code snippet code engine that we presented in this paper and others. Likewise, we hope to implement these interfaces using real world APIs to demonstrate their practicality, and pursue implementing a GUI library for web development to make use of these principles.

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References

ALEXA. 2010. Alexa website audience information. http://www.alexa.com/, March 16, 2010.

ANDRONICO, P., BUZZI, M., AND LEPORINI, B. 2004. Can i find what i'm looking for? In *WWW Alt. '04: Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters*, ACM, New York, NY, USA, 430–431.

APARTMENTS.COM. 2010. Apartments.com apartment search engine. www.apartments.com, March 4, 2010.

BAILEY, B. P. 2009. Overview of tcuid. In *Principles of User Interface Design, Implementation, and Evaluation*, https://agora.cs.illinois.edu/display/cs465/Home.

BING. 2010. Bing travel. http://www.bing.com/travel/, March 4, 2010.

BLACKMON, M. H., POLSON, P. G., KITAJIMA, M., AND LEWIS, C. 2002. Cognitive walkthrough for the web. In *CHI '02: Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM, New York, NY, USA, 463–470.

CAZOODLE. 2010. Cazoodle apartments. http://apartments.cazoodle.com/genti/, March 4, 2010.

HEARST, M. A. 2009. The design of search user interfaces. In *Search User Interfaces*, Cambridge University Press, 32 Avenue of the Americas, New York, NY 10013-2473, USA, 1–10.

HUANG, L., ULRICH, T., HEMMJE, M., AND NEUHOLD, E. J. 2001. Adaptively constructing the query interface for metasearch engines. In *IUI '01: Proceedings of the 6th international conference on Intelligent user interfaces*, ACM, New York, NY, USA, 97–100.

ORBITZ. 2010. Orbitz travel. http://www.orbitz.com/, March 4, 2010.

SIMPLYHIRED. 2010. Simplyhired job search. http://www.simplyhired.com/, March 4, 2010.

VAUGHAN, M. W., AND RESNICK, M. L. 2006. Search user interfaces: Best practices and future visions. In *Journal of the American Society for Information Science and Technology*, Wiley InterScience, 777–780.

WHITE PAGES. 2010. The white pages. http://www.whitepages.com/, March 4, 2010.

ZABA. 2010. Zaba people search. http://www.zabasearch.com/, March 4, 2010.

ZILLOW. 2010. Zillow real estate search. http://www.zillow.com/, March 4, 2010.