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## **Fenix - Personalized Information Filtering System for WWW Pages**

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## Keywords

Internet, World Wide Web, Information retrieval, Agents

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## Abstract

Nowadays the Internet offers a large amount of information to a wide range of users, making it difficult to deal with. The present work suggests the use of intelligent agents for the personalized filtering of Web pages. A set of autonomous, non-mobile and adaptive agents was developed, aiming to satisfy the user's need for information. The agents learn from the users' feedback and attempt to produce better results over time. This work presents the system description and the promising results of tests performed in a simulated environment. The proposed system has proven to be a useful tool in reducing the amount of information with which the user has to deal.

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## Introduction

The exponential increase in the amount of information available on the Internet has been causing a significant impact on users. The World Wide Web (WWW) has made the Internet accessible to a wide range of users. Although the increase of the information available facilitates the spreading of knowledge and the acquisition of products and services, it also makes the search for relevant material a real challenge. Questions arise as how the users will be able to locate the information they need, or how they will find the best offer for a service. The use of agents is a possible solution to this problem. Agents can be defined as software with the aim of performing tasks for their users, usually with autonomy, playing the role of personal assistants.

The present work suggests the use of intelligent agents for personalized information filtering. The proposed system is composed of a set of autonomous, adaptive and non-mobile agents aiming to satisfy the user's need for information. The agents receive the user's feedback about the relevance of the retrieved information and improve their search, obtaining better results over time.

The set of agents is autonomous, as it can perform its task without the user's presence, based on a previously built preference profile. The system is adaptive as it learns the user's preferences and adapts itself when these change over time. The agent's learning mechanisms are relevance feedback (Rocchio, 1971) and genetic algorithms (Goldberg, 1994). The information is represented by the vector space model (Salton, 1989), where queries and documents are represented as vectors in a vector space. This method was chosen for its efficiency, which has been proven in various works in the area of information retrieval (Sheth, 1994; Balabanovic, 1997) and for its relatively easy implementation.

The results presented were obtained through a series of sessions with simulated users. The system's efficiency evaluation was made through the normalized distance performance measure (NDMP), suggested by Yao (1995).

## Backgrounds and definitions

The purpose of this section is to introduce basic concepts and definitions which lay a basis for the system designs and experiments to follow. We present an overview of agent concepts; gives an approach of the information filtering systems and describe the relevance feedback technique.

### Agents

According to *Webster's New World Dictionary* (Guralmile, 1970), the definition of agent is: "a person or thing that acts or is capable of acting or is empowered to act for another". However, the meaning of the word can vary according to its context. In recent years, its use in the area of computer science has become more and more popular. But there is no common definition for "agent" in the context, perhaps because there are several investigations areas covered by the study of agents.

For the purposes of this work, the definition given by Caglayan and Harrison (1997) will be adopted: a software agent is a "computer entity that performs tasks delegated by the user in an autonomous way". Some characteristics are essential to the agents' concept as, for instance:

- *Intelligence* – the degree of reasoning and learned behavior, the agent's ability to accept the user's statement of goals and carry out the task delegated to it.
- *Autonomy* – the agent's capacity to control its own actions.
- *Social capacity* – the agent's ability to communicate with others agents, and with the users, generally through a language of communication among agents.
- *Mobility* – the agent's capacity to move in the environment. A mobile agent software is the one capable of being transported from one machine to another during its execution.

The agents can use, or not use, the abilities mentioned above in order to execute the delegated tasks. According to the abilities used, they can be classified as: intelligent agents, mobile agents, mobile and intelligent agents, and so on.

The agents can also be classified according to the tasks they execute, such as:

- information filtering agents;
- information retrieval agents;
- recommendation agents;
- agents for electronic market;
- agents for network management.

### Information filtering systems

The information filtering task involves repeated interactions over multiple sessions with the users having long-term goals. It differs from the information retrieval systems, where the users typically have a short-term information need that is satisfied in a single session. Information filtering systems assist users by filtering the data stream and delivering the relevant information to the user. Information preferences vary greatly across users, thus, filtering systems must be highly personalized.

### Relevance feedback

One of the most important and difficult operations in information retrieval is to generate queries that can succinctly identify relevant documents and reject the irrelevant ones. Users often submit queries containing terms that do not match the ones used to index most of the relevant documents and almost always many unretrieved relevant documents are indexed by different terms from the ones in query. This problem has long been recognized as a major difficulty in information retrieval systems.

Since the difficulty in accomplishing a successful search at the first attempt is recognized, it is common to perform iteratively searches and reformulate query statement based on the evaluation of previously retrieved documents. The relevance feedback method is usually adopted for automatically generating improved query formulations. A query can be improved iteratively by using an available query vector (of terms) and adding terms from the relevant documents, while subtracting terms from the irrelevant ones. A single iteration of relevance feedback frequently produces improvements of 40-60 per cent in the search precision (Salton, 1989). There are some classical ways to calculate the modified query. A more detailed discussion can be found in Baeza-Yates and Ribeiro-Neto (1999).

## Fenix system

In the information filtering system proposed, an agent is modeled as a set population of individual profiles. As a whole, all the profiles in a set try to satisfy the user's interests and adapt themselves to these interests.

The agent is responsible for starting the execution of search and filtering tasks, one for each profile. As the tasks are autonomous, they are sub-agents in the Fenix system. Each sub-agent, using different search engines, goes through the Web pages looking for documents containing the keywords provided by the user. The set of documents obtained undergoes the filtering process, according to the adopted model. The selected documents are the ones with the higher degree of similarity with the respective profile. The agent has to gather the results from all the sub-agents, classify them according to their potential relevance, and present them to the user. The user can provide positive or negative feedback for the documents. User feedback has the effect of modifying the profile used to retrieve that document.

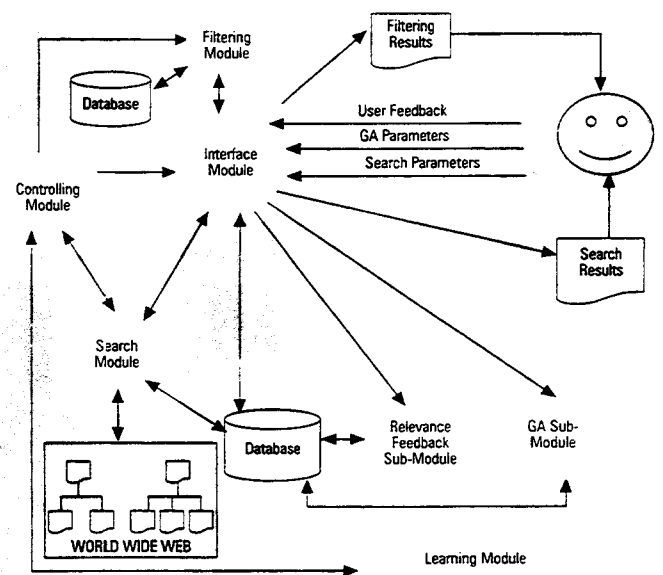
### Development methodology and environment

The Fenix system was developed according to the object-oriented approach. The programming language adopted was Java, by Sun Microsystems Inc., and the development environment was Jbuilder Standard 1.0, by Borland Corporation, that uses JDK (Java Development Kit) version 1.1. Java language allows the implementation of two kinds of programs: applets and applications. The applications run on any platform with Java Virtual Machine (JVM), while applets are special programs designed to be executed from HTML pages. The Fenix system was implemented as a Java application to be run locally.

### Architecture

The Fenix system is composed of five functional modules (see Figure 1). The modules are implemented as groups of related classes. The description of each module is given below.

Figure 1 Fenix system architecture



### User interface module

This module presents a graphic interface to interact with the user. The user's interaction with Fenix system begins with his registration, where he must inform his personal data and choose a login and a password. After identification the user can choose from three options: to create a new agent, to load an existing one or to activate the autonomous mode.

When creating a new agent, the user must choose a name and a background color, and provide the following search parameters: maximum number of documents shown per session (default is 30); and the query expression. A query in the Fenix system is a combination of keywords (technically called terms), separated by blank spaces. The use of logical connectives is not allowed. The presence of the connective *and* between the terms is automatically assumed.

As a result of the initial search, a series of retrieved documents is presented. After reading the chosen documents, the user can provide positive (+ 1) or negative (- 1) feedback according to their relevance.

When saving a newly created agent, the references to the documents with positive feedback will be saved (their URLs) and the term vector and their weights will be created, building the initial profiles for that agent.

When loading an existing agent, the user can choose one of three actions: to read some retrieved document, to provide feedback about some document, or to start a new search for documents.

The Fenix “autonomous mode” works performing search and filtering tasks based on the user’s profiles without his interaction.

### Search module

This module is responsible for gathering information from Web pages about the chosen subject and saving it in a local database. With the development of this work, there was a choice of using existing search engines, such as Altavista[1], Lycos[2] and others. Then, the search module became responsible for making the interface with these mechanisms.

The system keeps a list of search engines as part of its configuration parameters. The user’s keywords are provided to those engines and the first page of results retrieved for each one of them are converted to the string form and processed by the search module. The processing includes going through the pages identifying all the significant links, extracting the textual content of the pages pointed by the links and delivering this content to the filtering module.

### Filtering module

The filtering process consists of translating the documents provided by the search module to their vector representations, calculating the similarity between documents and profiles, and selecting the top-scoring documents for presentation to the user.

#### *Profiles and documents representation*

The representation adopted in this work is based on the vector space model (VSM) (Salton, 1989). According to it, documents and queries are represented as vectors in a hyper-space. A metric distance, which measures the proximity between vectors, is defined over space. The filtering results are the documents with representation that have the highest degree of proximity to the query vector.

A standard method for indexing texts consists of removing punctuation marks, recognizing individual words, eliminating functional words (“and”, “that”, etc.) using a stop-list, and using

the remaining words for content identification of the text. Since the terms are not equally important for content representation, weights are assigned to them, in proportion to their presumed importance to content identification purposes. A text is then represented as a vector of terms  $T_i = \{W_{ij}\}$ , where  $W_{ij}$  represents the weight of term  $t_j$  in text  $T_i$ .

In the representation adopted, the term weight is the product of the term frequency (TF) and the inverse document frequency (IDF). The TF is the occurrence frequency of the term in the text and it usually reflects the relevance of this term. The IDF is a factor that enhances the terms that appear in few documents, while it devaluates the terms occurring in many documents. As a result, the specific features of the documents are highlighted, while the ones spread through the set of documents have minor importance. The weight of the terms is then given as:

$$W_{ij} = tf_{ik} \times idf_k, \quad (1)$$

where  $tf_{ik}$  is the number of occurrences of term  $t_k$  in document  $i$ , and  $idf_k$  is the inverse document frequency of term  $t_k$  in the collection of documents. A commonly used measure for IDF is  $idf_k = \log(N/nk)$ , where  $N$  is the total number of documents in the collection, from which  $nk$  contains a term  $t_k$ . In this work, a collection of documents is formed by all the documents retrieved by a profile.

A profile is a set of information about the retrieved documents as, for example, their location in the Net (URL) and the user’s feedback assigned to them. Besides this, it contains the vector representation of documents that got positive feedback. The representation consists of a vector of terms similar to the one previously described for documents.

#### *Evaluation of filtered documents*

A commonly used similarity measure in the vector space model is the cosine of the angle between vectors. In the proposed application, different formulae were tested, and the one proposed in Salton (1989) was adopted.

#### *Scoring and selecting documents*

The documents retrieved through the search task started by the respective profile will have their similarities calculated in relation to that

profile. The agents are responsible for gathering the documents generated by all the profiles, classifying them according to their similarity values, eliminating repetitions and presenting them to the user.

The similarity values are converted to a class scale to be presented to the user. A five-point scale was adopted, with the adjectives:

- (1) Terrible: for scores equal to 0.2.
- (2) Poor: for scores between 0.2 and 0.3.
- (3) Neutral: for scores between 0.3 and 0.5.
- (4) Good: for scores between 0.5 and 0.8.
- (5) Excellent: for scores greater than 0.8.

The maximum score value is 1.0 and it only happens when the profile and the document representations are identical. In this work, the limit of 0.2 was adopted as the minimum score that a document should have in order to be presented to the user.

### Learning module

The learning methods adopted by the system are relevance feedback and genetic algorithms. Both methods were projected as independent sub-modules and only the relevance feedback has been implemented at the present stage. In the next stage, the genetic algorithm will be implemented as a complementary mechanism, introducing diversity to the search parameters used by the agents as a goal.

#### *Relevance feedback sub-module*

The user's feedback for a document has the effect of modifying the respective profile. The profile has to incorporate the changes before new documents can be evaluated.

In the relevance feedback method, an original query vector (represented by the profiles) is modified based on the user's feedback for the documents retrieved by the profile.

For vector space representations, the method for query reformulation in response to user's feedback is vector adjustment. Since queries and documents are both vectors, the query vector is moved closer to the vector representing documents with positive feedback, and further from the vectors of the documents with negative feedback. This affects the weight of the terms already existing in the profile by modifying them in proportion to the feedback. The terms not existing in the profile must be added to it.

### Other modules

The Fenix system database is composed of all information from the user, his agents and respective profiles, as well as the documents retrieved in searches. This database is implemented through a group of classes existent in Java standard APIs. Users' and agents' data are stored in simple text files. Profiles and documents are stored in object files.

Besides all of these modules, Fenix has a controlling module (see Figure 1) responsible for controlling the global behavior of the system, the behavior of each user's set of agents and the specific behavior of each individual agent.

### Analysis of results

In this work, the performance measure proposed by Yao (1995) was adopted. The ndpm measure (normalized distance-based performance measure) is a distance, normalized to range from 0 to 1, between the user's classification for a set of documents and the system's classification for the same documents. This will provide a relative measure, that will be more appropriate to the system's goal than recall and precision measures, commonly used in information retrieval.

An outline was adopted as suggested in Balabanovic (1997). A special list of documents is supplied to a simulated user who should classify it in agreement with his interests in a subject. That list is randomly selected from several documents retrieved from the Web. The system also ranks the documents according to how well they match the profile previously built for that user. The expected result is for the ndpm distance between the user and system classifications to decrease gradually over time, as the user's profile is adjusted.

A total of 100 agents were created for 30 subjects of interest of a simulated user. For each agent, six simulated sessions of user-agent interaction were performed. After an initial search, the agent classified the retrieved documents according to the categories above, the "user" evaluated the documents, providing their feedback values and classification. With the feedback, the agent's

profile was adjusted to later searches and, with the classification, the ndpm distance was calculated.

A progressive decrease of that distance in the course of the sessions (see Figure 2) was observed, indicating that the agents were adapting themselves to the user's preferences, increasing, then, the probability of retrieving a larger number of relevant documents and discarding the irrelevant ones.

The obtained results are similar to the ones described in Balabanovic (1998), where a multiagent system was implemented for the WWW pages recommendation. Balabanovic proposed an architecture that combined content-based with collaborative filtering. His system performance was also evaluated with the ndpm measure and the obtained curve had a behavior quite similar to the one presented in the tests with Fenix (see Figure 2). In his work, 25 evaluation sessions were performed. The initial average ndpm values were 0.4 and the final values were 0.001.

Several system configuration parameters were tested in the simulated sessions. To sum up the final results we can say that the system reaches the best performance when the query expression is more specific, the agents are composed of at least four and a maximum of ten profiles, and the term vectors of the documents have maximum size of 300 terms.

## Conclusions

An information filtering system must be capable of becoming specialized according to user's interests, adapting to changes and exploring the domain of potentially relevant information.

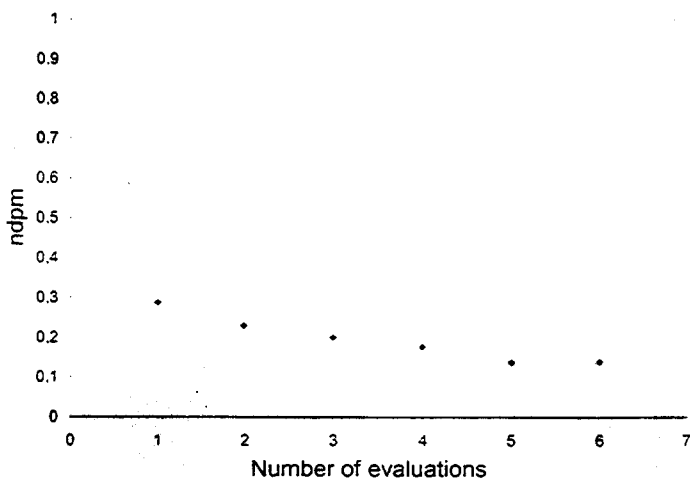
The results of simulated tests using the ndpm distance in a controlled environment were quite satisfactory. The tests showed that the distance between the evaluation provided by the user and the one provided by the agents decreased in the course of the sessions, indicating the agents' adaptation to the user's interests. These results demonstrate that the relevance feedback technique alone is very efficient for the agent to become specialized in the user's specific interests.

The performance values obtained in simulated tests based on the ndpm measure were similar to the ones found in other works of information filtering. Balabanovic (1998) proposed an approach that combines content-based and collaborative techniques applied to the WWW pages recommendation. The results described in his work were quite similar to those obtained with Fenix, where a simpler architecture was adopted.

A question that has arisen in the tests was the low scalability of the system. As a future work, a possible solution for that problem is the implementation of a system with multiple search agents collecting Web pages in several sources. The search agents would deposit the pages obtained in a central repository where individual users' personal agents would recover those that best satisfied the users' profiles. The supplied feedback would go both to the personal agent (that would adjust the user's profile) and to the search agents, that would be serving the users' groups instead of individual users and taking advantage of the shared interests.

The impact of systems like Fenix on an enterprise may be quite significant. Several information search tasks could be automated, as the system is able to filter and classify different subjects of interest, therefore reducing the consumption of time and money spent on those activities. Information filtering agents hold great promise to the management of extensive available information.

Figure 2 Average ndpm between user and system rankings, over all agents at evaluation points



## Notes

- 1 Available at <http://www.altavistadigital.com>
- 2 Available at <http://www.lycos.com>

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