A Reconfigurable Mobile Agent Architecture Enhanced with Relevance Feedback Mechanism for Interactive Multimedia Retrieval

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Abstract. Since multimedia information is characterized by motley types of media with different properties, multimedia content retrieval in digital libraries requires dynamic reconfigurable architectures. In this paper, mobile agents are being used as the basis of such architecture. The concept of remotely configurable mobile agents can effectively assist applications that require a certain degree of customization such as feedback mechanisms. The proposed architecture is further enhanced with innovative relevance feedback algorithms for interactive multimedia retrieval. More specifically, an optimal recursive relevance feedback mechanism is examined by adaptively estimating a parametric correlation-based similarity measure. Then, the energy of the weights corresponding to a particular descriptor category is computed and then the system is reconfigured so that important descriptors are analyzed in detail.

1 Introduction

New multimedia applications such as content based retrieval, multimedia organization, browsing and navigation of audiovisual content, semantic content description, web ontologies and web mining require new tools and algorithms for efficient and reliable management and organization of multimedia content [1], [2]. In this paper, an efficient dynamic learning scheme is proposed for updating not only the similarity measure used for ranking multimedia data, but also configuring the system while it is functioning, resulting in a reconfigurable dynamic architecture. Mobile agents are being used as the basis of the proposed a dynamic reconfigurable scheme yielding to a highly dynamic multimedia retrieval system which allows adding and removing components at run-time. The presented architecture allows run-time addition or removal of system components based on interaction by the user, who provides information about the relevance (irrelevance) of the content.

2 System Architecture Overview

The proposed architecture consists of three main modules; the acquisition, the adaptation and the retrieval module.

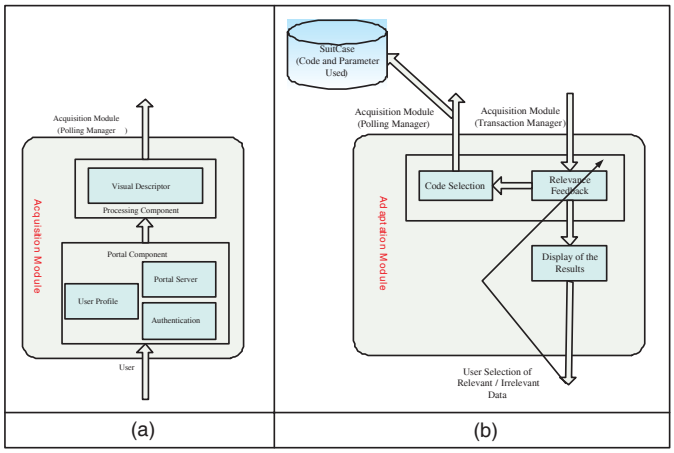

Fig. 1. The block diagram of the (a) acquisition and (b) adaptation module.

The Acquisition Module The internal architecture of the acquisition module consists of two main components; the Portal and the Processing component. The portal component is responsible for receiving user's queries. The goal of the processing component is to apply processing algorithms on the submitted visual data (query) before the retrieval module initiates the retrieval process.

The Retrieval Module The retrieval module is responsible for creating and dis-patching the mobile agents used for mining and retrieving multimedia information. The Retrieval module consists of two platforms; The Home and the Destination platform. The home platform is used for activating, polling and monitoring the mobile agents, while the destination platform refers to the remote web site in which the mobile agent is sent. A set of mobile and stationary agents are embedded in the home platform unit:

- Polling Manager: The main task of the polling manager is to decide whether a new instance of a Travel Agent has to be created at a particular time.
- Transaction Manager: The Transaction Manager is a stationary agent responsible for instantiating and launching Travel Agents when triggered by the Polling Manager.
- Travel Agent: The Travel Agent is a mobile agent, capable of fetching information. The Travel Agent can carry all necessary parameters for conducting the acquisition process. These parameters are stored in the suitcase database created by the Transaction Manager and the adaptation module.

- Data Source Broker: This stationary agent maps the set of submitted data into the corresponding destinations where the desired information might be found.
- The Search Criteria Manager: The search criteria manager is a stationary agent that encapsulates the knowledge for selecting the appropriate algorithms for retrieving and processing multimedia data.

The destination platform comprises the general and the service agent, described in the following.

- General Agent: The General Agent is a stationary agent constituting the mediator between the arriving travel agent and the service agent, which performs the actual information extraction.
- Service Agents: Service Agents are stationary agents that perform the information extraction from the web data sources All the retrieval results are stored in a database, so that they can be accessed by the other modules.

The Adaptation Module: The purpose of the adaptation module is to reconfigure the system according to the user's information needs and preferences. To accomplish this objective we incorporate a relevance feedback mechanism, which is the core component of this module. There are also two additional components, the Display of the Results and the Code Selection component respectively.

3 Profile Estimation

The profile estimation is based on a relevance feedback algorithm. Relevance feedback is an on-line learning strategy for updating the system response according to the user's information needs and preferences [3], [4] and [5]. A parametric similarity measure is used for retrieving multimedia data, the parameters (weights), say w_i which indicate the degree of importance of each descriptor. An on line learning strategy as described in [6] is being used in this paper for the weight estimation.

The energy of the weight descriptors belonging to a particular category (e.g. color or shape) is calculated

$$E_{c_j} = \frac{\sum\limits_{i \in C_j} w_i^2}{\|C_j\|} \tag{1}$$

where C_j refers to a particular descriptor category.

Then, the algorithm estimates all the categories $C_{\widehat{j}}$ whose respective energy contributes more (defined by a factor α) to the total energy, i.e.,

$$\widehat{j} : \sum_{j} E_{w_{c_{\widehat{j}}}} = \alpha \cdot E \tag{2}$$

where E refers to the total energy, i.e., $E = \sum\limits_{j} E_{w_{c_j}}$,while factor α usually equals to 80%.

4 Reconfiguration

In this component, we estimate the appropriate code to be used by the mobile agents. The algorithm is based on the results of the relevance feedback component. More specifically, the code and software components which correspond to the descriptors of highest energy (importance) are selected. The selected codes are stored in the suitcase database, in which mobile agents mine and retrieve multimedia information.

This means that the descriptors of the selected categories are the most important to the user's profile and therefore, these descriptors should be analyzed in more details in the following retrieval iteration. On the contrary the descriptors corresponding to the categories of low energy (less significant categories) are ignored. In this way, a "multi scale" processing of visual data is accomplished oriented to the current preferences of users.

In the following, a new retrieval process is activated implemented by the mobile agent architecture. However, in this case new codes are embedded to the mobile agents so that the visual data will be processed in accordance with the current user's information needs.

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