Semantic Information Representation and Ontologies

1. Research Team

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2. Statement of Project Goals

A primary goal of this project is to design, develop, test, enhance, and integrate techniques and mechanisms for specifying the semantic content in units of multimedia information. By the semantic content of a multimedia object O, we refer to the meaning-based categories into which O may be classified, such as "students", "research projects", and "key research projects", as well as the relationships between O and other objects, such as "taught by", "project member of", "decibel high".

A second aspect of this project has been to employ knowledge about the information being presented and knowledge about the user and/or their system interaction history to customize presentations (immersive experiences) for the user. This can employ ontology-based techniques, and/or techniques based upon user behavioral immersidata (data generated by user interactions with the system).

3. Project Role in Support of IMSC Strategic Plan

The representation of meta-data (information describing multimedia information units) is needed for each of the three vision applications, as well as several of the efforts in the application research projects (specifically I4 and the speech projects). For example, with regard to the 2020Classroom, we require the ability to represent the (dynamic) content of educational experiences, and locate relevant information in response to student inquiries; for this, we must understand the concepts and relationships involved.

4. Discussion of Methodology Used

Perhaps two of the most long-standing open and critical problems in information technology are natural language understanding, and image understanding. While significant strides have been made over the years in sub areas of these open problems, such as object and person recognition, speech processing, natural language summarization and translation, identification of "similar" images by signal processing and related techniques (such as color histograms and techniques, there remains a lack of general techniques for representing and extracting the semantic meaning

of multimedia information objects. Research in the IM sub area of *media content extraction and management* focuses on advancing capabilities in this area, with a complementary focus of this sub area being on representing the semantic meaning acquired, inferences that can be made. We choose an approach based upon the use of a descriptive domain-specific dynamic ontology to express this knowledge. An additional important focus has been on developing user historical data representation techniques to record user actions, and customize the user's experience based upon these.

5. Short Description of Achievements in Previous Years

This is a somewhat refined research sub area within IM – IM was reorganized slightly in response to the last NSF major site visit and panel review. In prior years, we stressed results on effective acquisition and analysis of behavioral immersidata (data acquired from the user during an immersive session). Customization of immersive experiences by analysis of immersidata can be quite effective, as we detailed in the previous annual report. This work is continuing, and is expected to play a central role in the 2020Classroom.

5a. Detail of Accomplishments During the Past Year

A key result involves the study of the use of human temperament, possibly accompanied by an ontology to customize the information we present to a given user at a given time. We note that human temperament has been identified as a predominant factor of the patterns of human behavior by psychologists [1]. In addition, neuroscience research indicates that temperament is an innate property of the brain [2]. The inherent inter-related patterns between user temperaments and user interests may lead to a better understanding of user personality and improve the service of an information system. Consequently, we study temperament-based filtering to incorporate the concept of human temperaments into the filtering process of an information recommendation service [3, 4]. We hypothesized that the accuracy of an information recommendation system can be improved by employing human factors, particularly human temperament, for filtering and customization.

An experimental prototype system has been developed, implemented and tested to demonstrate the effectiveness of the proposed temperament-based filtering approach. A user-studies testing was conducted on a web site and a simulation model also employed. Furthermore, varied heuristic selection rules are applied by the filtering agent when it interacts with the simulated user under different task situations and the results outperform content-based filtering [5].

Our work on ontologies has been applied to several IMSC projects, including the predecessor of I4, which was a system to generate customized (audio) "stories" in response to a user request. Here, to improve the accuracy in terms of precision and recall of an audio information retrieval system we created a domain-specific ontology (a collection of key concepts and their interrelationships), as well as a novel, pruning algorithm. Given the shortcomings of keyword-based techniques information selection techniques, we opted to employ a concept-based technique utilizing this ontology. Achieving high precision and high recall is the key problem in the retrieval of audio information. In traditional approaches, high recall is typically achieved at the expense of low precision, and vice versa. Through the use of a domain-specific ontology,

appropriate concepts can be identified during metadata generation (description of audio) or query generation, thus improving precision [6-8].

When irrelevant concepts are associated with queries or documents there is a loss of precision. On the other side of the coin, if relevant concepts are discarded, a loss of recall will ensue. In conjunction with the use of a domain specific ontology we have thus proposed a novel, an automatic pruning algorithm eliminates as many irrelevant concepts as possible. Through the association of concepts in the ontology, through techniques of correlation, this pruning algorithm presents a method for the selection of concepts in the query generation. To improve recall, a controlled query expansion mechanism is utilized for the improvement of recall, thus guaranteeing that precision will not be lost.

We have constructed a demonstration prototype with a focus on audio data. We have experimentally and analytically we have shown that our model, compared to keyword search, achieves a significantly higher degree of precision and recall. Furthermore, the techniques employed can be applied to the problem of information selection in all media types.

6. Other Relevant Work Being Conducted and How this Project is Different

A good deal of work is being done these days on representing meta-data. This work has its roots in the programming language, database management, document retrieval, and artificial intelligence areas. XML, for example, is a proposed standard for data and meta-data, but it is relatively low-level "knowledge" that we can represent. The semantic web efforts [9], and RDF [10] project relate directly to our work, and we are participating in these efforts.

With regard to uniqueness, no one to our knowledge has studied the user of human temperament for customization in information selection and presentation. We are also the first to extensively study behavioral immersidata, and its use in customization and analysis (e.g., of a student's learning progress).

7. Plan for the Next Year

Leading our plans for next year is a careful analysis of the use of ontologies and customization in each of the three recently-restructured vision applications; education, communication, and entertainment. Our initial main focus will be in the education area, working on the synergistic use of ontology-based enhancement of user interactions with historical user immersidata analysis.

Another key focus will be on the construction of an ontology management system, to aid in the process of creating and refining an ontology. Complementary with this, we are pursuing SVD techniques for deriving new "topics" or potential concepts for the (dynamic) ontology via data mining.

8. Expected Milestones and Deliverables

- A rich news-oriented sports ontology for the I4 project.

- A synergistic approach and system for combining ontologies with immersidata for customization (in education).

- A study of multi-ontology integration (partial) and cross-ontology correlation, given the requirements provided by the vision applications.

- A demonstration of the effectiveness of an ontology in customizing immersive news presentations.

- A multi-level/perspective ontology for the earthquake science domain. Here, we are trying to validate the generality of our approach, and also to specifically contribute to earth science studies in collaboration with NASA and JPL.

9. Member Company Benefits

We have worked with and have been partially supported by IBM (and the former Informix, now part of IBM). We have also worked directly with NCR, with some technology transfer of behavioral immersidata analysis techniques.

We now also have a new direct connection with earthquake science research at JPL, which has a strong requirement for the kinds of ontology and user modeling techniques we are developing. We now have substantial support from NASA on an application study directly connecting to this research sub area.

10. References

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