A Survey on Multimedia Data Mining and Its Relevance Today

Manjunath T.N[1], Ravindra S Hegadi[2], Ravikumar G K[3]

[1]Research Scholar, Bharatiar University, Coimbatore Tamilnadu, INDIA

[2]Asst.Prof Karnatak University,Dharwad Karnataka,INDIA

[3]Research Scholar,Dr MGR University,Chennai Tamilnadu,INDIA

Abstract:
Over the past decades, data mining has proved to be a successful approach for extracting hidden knowledge from huge collections of structured digital data stored in databases. From the inception, Data mining was done primarily on numerical set of data. Nowadays as large multimedia data sets such as audio, speech, text, web, image, video and combinations of several types are becoming increasingly available and are almost unstructured or semi-structured data by nature, which makes it difficult for human beings to extract the information without powerful tools. This drives the need to develop data mining techniques that can work on all kinds of data such as documents, images, and signals. This paper explores on survey of the current state of multimedia data mining and knowledge discovery, data mining efforts aimed at multimedia data, current approaches and well known techniques for mining multimedia data.

Keywords:
Data mining, Multimedia Data Mining, Multimedia database, Association, Clustering, Classification

1. INTRODUCTION

With the recent advances in electronic imaging, video devices, storage, networking and computer power, the amount of multimedia has grown enormously, and data mining has become a popular way of discovering new knowledge from such a large data sets. Note that to mine multimedia data we must mine combination of two or more data types such as text and video, or text, video and audio. One solution is to develop mining tools to operate on the multimedia data directly.

1.1 What is Multimedia Data Mining

Multimedia Data refers to data such as text, numeric, images, video, audio, graphical, temporal, relational and categorical data. Multimedia data mining refers to pattern discovery, rule extraction and knowledge acquisition from multimedia database [1]. Figure 1.1 illustrates multimedia data mining, in particular, various aspects of multimedia data mining[2].

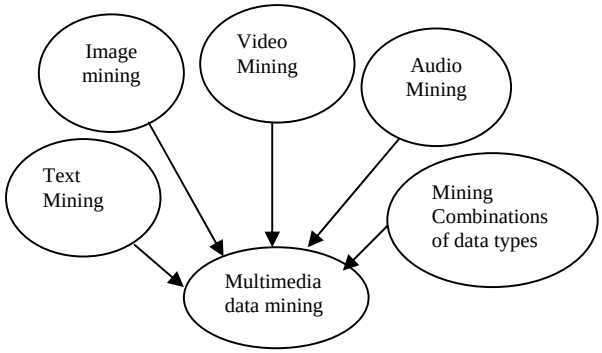

Figure 1.1: Multimedia data mining

1.1.1Motivation for multimedia data mining

Tremendous benefits of traditional data mining is proven for structured data. Now its time for extending the mining techniques for unstructured, heterogeneous data.

1.1.2Why mining of multimedia data -- Potential applications

It is well known that multimedia information is ubiquitous and often required, if not essential in, many applications. Consider the application areas of MDM and related industries who are users of technology.

Multimedia Data Mining in Digital Libraries [3] — the digital library retrieves collects stores and preserves the digital data. For this purpose, there is a need to convert different formats of information such as text, images, video, audio, etc. The data mining techniques are popular while conversion of the multimedia files in the libraries.

Multimedia data mining for traffic video sequences [4] -- The analysis & mining of traffic video sequences to discover important but previously unknown knowledge such as vehicle identification, traffic flow, queue detection, incident detection & the spatio temporal relations of the vehicle at intersection, provide an economic approach for daily traffic monitoring operations.

Multimedia data mining approach for automated event analysis of suspicious movements -- Many government

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organizations, multi-nationals companies, shopping malls, banks and etc are using surveillance system to monitor movements of employees, visitors, machines etc. An ultimate objective of such surveillance system is to detect suspicious person based on their movements to maintain security and avoid any casualty.
Application in medical analysis -- Application of Data Mining Techniques for Medical Image Classification
Media Production and Broadcasting [5] – Proliferation of radio stations and TV channels makes broadcasting companies to search for more efficient approaches for creating programs and monitoring their content.

1.1.3 Multimedia Data Mining – On What Kind of Data
Multimedia data mining is being put into use and studied for databases, including multimedia databases and unstructured and semi structured repositories such as the World Wide Web.
Multimedia Databases: Multimedia databases include video, images, and audio and text media. They can be stored on extended object-relational or object-oriented databases, or simply on a file system.
World Wide Web: The multimedia is becoming increasingly available on the World Wide Web which can be viewed as a large, distributed, multimedia database. However the data is unstructured and heterogeneous. Data in the World Wide Web is organized in inter-connected documents. These documents can be text, audio, video, raw data, and even applications.

2. DATA MINING VERSUS MULTIMEDIA DATA MINING

Current data mining tools operate on structured data, the kind of data that resides in large relational databases whereas data in the multimedia databases are semi-structured or unstructured. Often compared with data mining, multimedia mining reaches much higher complexity resulting from: a) The huge volume of data, b) The variability and heterogeneity of the multimedia data (e.g. diversity of sensors, time or conditions of acquisition etc) and c) The multimedia content's meaning is subjective [6].

2.1 Unstructured data

Unstructured data is simply a bit stream. Examples include pixel level representation for images, video, and audio, and character level representation for text. Substantial processing and interpretation are required to extract semantics from unstructured data [7]. This kind of data is not broken down into smaller logical structures and is not typically interpreted by the database

3. ARCHITECTURES FOR MULTIMEDIA DATA MINING

Various architectures are being examined to design and develop an multimedia data mining system. The first architecture includes the following. Extract data or metadata from the unstructured database. Store the extracted data in a structured database and apply data mining tools on the structured database [8]. This is illustrated in figure 3.1.

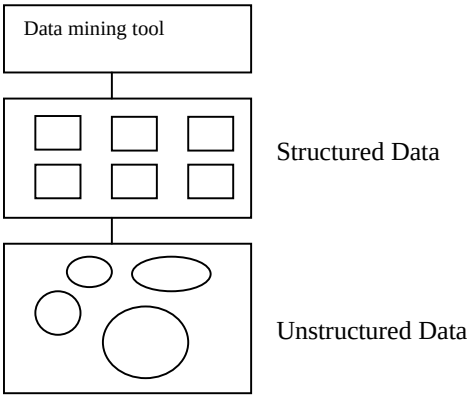

Figure 3.1: Converting unstructured data to structured data for Mining

Figure 3.2 present architecture of applying multimedia mining in different multimedia types [18]. Data collection is the starting point of a learning system, as the quality of raw data determines the overall achievable performance. Then, the goal of data pre-processing is to discover important features from raw data. Data pre-processing includes data cleaning, normalization, transformation, feature selection, etc. Learning can be straightforward, if informative features can be identified at pre-processing stage. Detailed procedure depends highly on the nature of raw data and problem's domain. In some cases, prior knowledge can be extremely valuable.

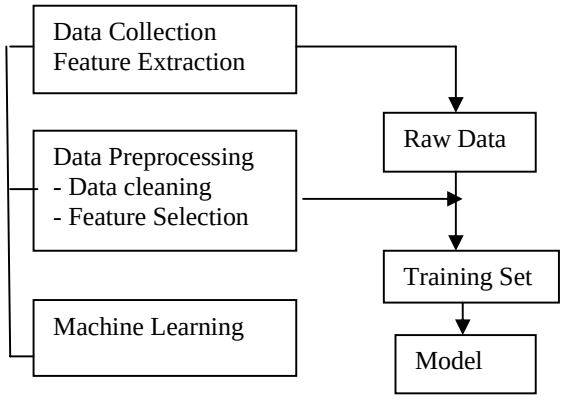

Figure 3.2: Multimedia mining process

For many systems, this stage is still primarily conducted by domain experts. The product of data pre-processing is the training set. Given a training set, a learning model has to be chosen to learn from it. It must be mentioned that the steps of multimedia mining are often iterative. The analyst can also jump back and forth between major tasks in order to improve the results [6].

Figure 3.3 present architecture of applying multimedia mining in different multimedia types [5]. Here the main stages of the data mining process are (1) domain understanding; (2) data selection; (3) leaning and preprocessing; (4) discovering patterns; (5) interpretation; and (6) reporting and using discovered knowledge. The domain understanding stage requires learning how the results of data-mining will be used so as to gather all relevant prior knowledge before mining.

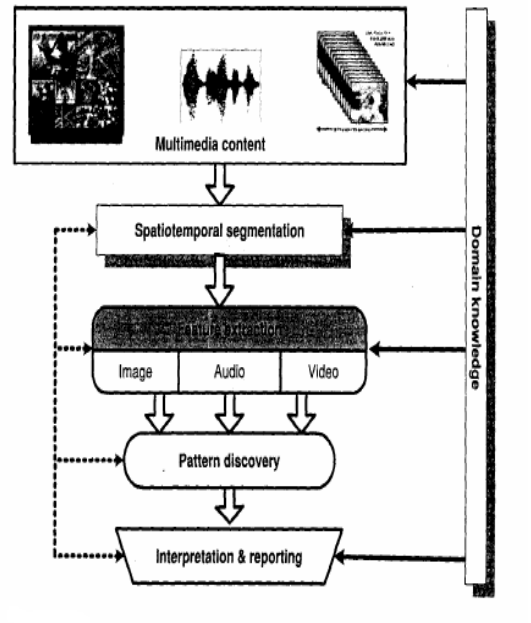

Figure 3.3: Multimedia data mining architecture

The data selection stage requires the user to target a database or select a subset of fields or data records to be used for data mining. A proper domain understands at this stage helps in the identification of useful data. The next stage in a typical data mining process is the pre-processing step that involves integrating data from different sources and making choices about representing or coding certain data fields that serve as inputs to the pattern discovery stage. Such representation choices are needed because certain fields may contain data at levels of details not considered suitable for the pattern discovery stage. The preprocessing stage is of considerable importance in multimedia data mining, given the unstructured nature of multimedia data. The pattern discovery stage is the heart of the entire data mining process. It is the stage where the hidden patterns and trends in the data are actually uncovered. There are several approaches to the pattern discovery stage. These include association, classification, clustering, regression, time-series analysis and visualization. The interpretation stage of the data mining process is used to evaluate the quality of discovery and its value to determine whether previous stage should be revisited or not. Proper domain understanding is crucial at this stage to put a value on discovered patterns. The final stage of the data mining process consists of reporting and putting to use the discovered knowledge to generate new actions or products and services or marketing strategies as the case may be[5].

4. ISSUES IN MULTIMEDIA DATA MINING

Before multimedia data mining develops into a conventional, mature and trusted discipline, many still pending issues have to be addressed. These issues pertain to the multimedia data mining approaches applied and their limitations. Major Issues in multimedia data mining include content based retrieval and similarity search, generalization and multidimensional analysis, classification and prediction analysis, and mining associations in multimedia data[9]. Multimedia data mining needs content-based retrieval and similarity search integrated with mining methods.Content based retrieval in multimedia is a challenging problem since multimedia data needs detailed interpretation from pixel values[15]. The objective of multi-dimensional analysis is to gain insight into the meaning contained in databases. The multi-dimensional approach makes navigating the database easier, screening for a particular subset of data, or asking for data in a particular way, and being able to define analytical calculations. Because the data is physically stored in a multi-dimensional structure, the speed of these operations is much quicker and more consistent than in other database structures[16].

5. MULTIMEDIA FEATURE EXTRACTION FOR MULTIMEDIA DATA MINING

It is noted that different image attributes such as Colour, edges, shape, and texture are used to extract features for mining. In the case of video, additional attributes resulting from object and camera motion are used. In case of audio, both the temporal and the spectral domain features have been employed. Examples of some of the features used include short-time energy, pause rate, zero-crossing rate, normalized harmonicity, fundamental frequency, frequency spectrum, bandwidth, spectral centroid, spectral roll-off frequency and band energy ratio[10].

6. APPROACHES TO MULTIMEDIA DATA MINING

For multimedia database mining, storage and search techniques need to be integrated with standard data mining methods. Promising approaches include the Construction of multimedia data cubes, the extraction of multiple features from multimedia data, and similarity based pattern searching. *Multimedia data cube* - which facilitates multiple dimensional analyses of multimedia data, primarily based on visual content. A multimedia data mining system prototype, Multimedia Miner has been designed and developed which includes the construction of a multimedia data cube which facilitates multiple dimensional analysis of multimedia data, primarily based on visual content and the mining of multiple kinds of knowledge, including characterization (summarization), discrimination (comparison), classification, association and clustering, in image and video databases.

Feature extraction - Feature extraction takes the information contained in multimedia data to extract patterns and derive knowledge from large collections of images, audio, video.

Similarity based pattern searching - Similarity search is a crucial task in multimedia retrieval and data mining. The similarity search is briefly defined as searching for a set of similar objects to a given query object.

Database approach – the database approach views multimedia data as structured. Features are extracted manually or semi-automatically. The features, referred to as attributes, entail a high level abstraction on unstructured data. the higher the level of abstarction in the features, the lower the scope for ad hoc queries.

7. MULTIMEDIA DATA MINING TECHNIQUES AND ALGORITHMS

The algorithm and techniques employed to perform multimedia data mining are most important. Data mining techniques are numerous. Many of these techniques may also be applied for multimedia data mining. Within the supervised framework, three data mining methods have been used. These are classification, association and statistical modeling. Within the unsupervised learning, clustering is another data mining methodology used.

7.1 Multimedia Data Mining Process Using Classification Rules

In this approach, we concentrate on discovering the semantic structures. We choose to use the classification rule approaches to perform data mining process because this approach only induce absolutely accurate rules. An early example of this is the work of Yu and Wolf[19], who used one dimensional Hidden-Markov Model for classifying images and video as indoor-outdoor games[4]. A recent work in this area is due to Shu-Ching Chen et al. presented a new multimedia data mining framework for the detection of soccer goal shots by using combined multimodal (audio/visual) features and classification rules using Decision Tree[17].

7.2 Multimedia Data Mining Process Using Clustering

Clustering is a process of organizing objects into groups whose members are similar in some way. It is one of the data mining techniques is an unsupervised learning. In unsupervised classification, the problem is to group a given collection of unlabeled multimedia files into meaningful clusters according to the multimedia content without a priori knowledge. A recent work in this area is due to Lei wang et al.[4], who introduced a clustering method based on unsupervised neural nets and self-organizing maps. Another recent work in this area is due to Jessica Lin et al. have presented an approach to perform incremental clustering at variuos resolutions, using the Haar wavelet transform using k-means as clustering algorithm.

7.3 Multimedia Data Mining Process Using Association Rules

Association rule learning is a popular and well researched method for discovering interesting relations between variables in large databases. There are different types of associations: association between image content and non image content features. An early example of applying association rule mining for image annotation is provided by the work of Ordonez and Omiecinski [12], who consider segmented images to compute the co-occurances of regions that are deemed similar[4]. Another recent work in this area is due to Tseng et al.[13], who proposed a new image classification method by using multiple-level association rules based on the image objects. Another recent work in this area is due to Ankur M. Teredesai et al.[14], who presented a multirelational extension to the FP-tree algorithm to accomplish the association rule mining task effectively. The motivation for using multi-relational association rule mining for multimedia data mining is to exhibit the potential accorded by multiple descriptions for the same image (such as multiple people labeling the same image differently).

7.4 Multimedia Data Mining Through Statistical Modeling

In this approach, a collection of annoted images is used to build models for joint distribution of probabilities that link image features and key words[4]. An early example of this approach is the work ok of Morie et al.[11], who used a

simple co-occurance model to establish links between words and partitioned image regions.

8. CONCLUSION

Multimedia data mining techniques are active and growing area of research now, in this paper we discussed mining multimedia objects. We first described the motivation for multimedia-data mining with applications and then discussed different approaches for mining multimedia mining. This paper also describes well known techniques for multimedia mining.

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Manjunath T N. received his Bachelor's Degree in computer Science and Engineering from SJC Institute of Technology, Chickballapur, Karnataka, india during the year 2001 and M. Tech in computer Science and Engineering from Jawaharlal Nehru National College of Engineering, Shimoga,Karnataka,india during the year 2004. Currently pursing Ph.D degree in Bharatiar University, Coimbatore. He is working as a project Lead in Wipro Technologies, Bangalore. He is having total 10 years of Industry and teaching experience. His area of interests are Data Warehouse & Business Intelligence, multimedia and Databases. He has published and presented papers in journals, international and national level conferences.

Dr.Ravindra S Hegadi is working as Asst.prof, Karnatak University Dharwad, Inida. He recieved his Master of Computer Applications (MCA) & M.Phil and Doctorate of Philosophy Ph.D. in year 2007 in computer science from Gurbarga University ,Karnataka, He is having 15 years of Experience. He has visited overseas to various universities as SME.His area of interests are Image Mining, Image Processing and Databases and business intelligence. He has published and presented papers in journals, international and national level conferences.

Ravikumar GK. received his Bachelor's degree from Siddaganga Institute of Technology, Tumkur (Bangalore university) during the year 1996 and M. Tech in Systems Analysis and Computer Application from Karnataka Regional Engineering College Surthakal(NITK) during the year 2000. Currently pursing PhD degree in Dr MGR University, Chennai. He is working as a Senior project Lead in Wipro Technologies, Bangalore. He had worked with IGATE Global solutions Bangalore and also has worked with SJBIT as Prof and HOD of Dept of CSE and ISE having around 14 years of Professional experienced which includes Software Industry and teaching experience. His area of interests are Data Warehouse & Business Intelligence, multimedia and Databases. He has published and presented papers in journals, international and national level conferences.