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Multimedia Data Mining- A Survey

Anuraag Vikram Kate [1] Nikilav P V [2] Giriesh S [3] Hari Prasath R S [4] Naren J [5]

[1]SASTRA University, School of Computing, Thanjavur, India
anuraag.avk@gmail.com
[2]SASTRA University, School of Computing, Thanjavur, India
nikilav.v@gmail.com
[3]SASTRA University, School of Computing, Thanjavur, India
girieshs@gmail.com

[4]SASTRA University, School of Computing, Thanjavur, India
hariprasathrs07@gmail.com

[5]SASTRA University, School of Computing, Thanjavur, India
narenjeeva3@gmail.com

Abstract: In the recent years, data quarrying or mining has been an effective as well as powerful approach for extracting concealed knowledge from huge collections of regulated digital data stored in databases. From the inception, data mining was being done predominantly on the 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, it difficult for us 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 sightsees 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, Data Warehouse, Data Mining Process

1. INTRODUCTION

Recent progress in the field of electronic imaging, video devices, storage, networking and computer power, show that the amount of multimedia has grown enormously, and data mining has become a popular and an easy way of discovering new knowledge from such large data sets i.e. diverse databases. Note that for mining multimedia data the combination of two or more data types such as text and video, or text, video and audio needs to be done which is not a simple procedure. One solution is to develop mining tools to operate on the multimedia data directly.

1.1 What is Multimedia Data Mining:

Multimedia data mining refers to the mining of Multimedia content.In other words, it is study of large amounts of multimedia information in order to find patterns or statistical relationships. Once data is collected, computer programs are used to analyze it and look for meaningful connections. This information can be used in marketing to discover consumer habits. But it is mainly used by governments to improve social

systems.Multimedia data mining tends to discover patterns, extractrules and refers to knowledge acquisition from multimedia database mining, in particular, various aspects.

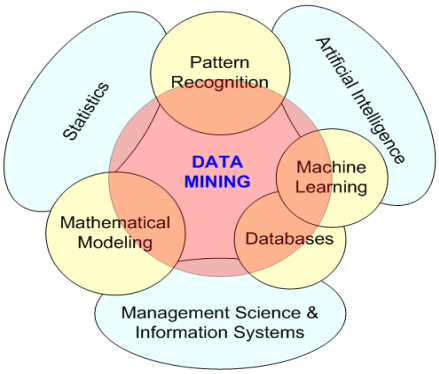


Fig 1.1

1.1.1 What is needed here:

The main requisite of Multimedia data mining is the collection of huge amounts of data. The key factor is the sample size when analyzing data because predicted trends and patterns are more likely to be inaccurate with a smaller sample. This data can be collected from various media, including videos, sound files, and images. Some experts also consider spatial data and text to be multimedia. Information from one or more of these media is the focus of data collection.

1.1.2 Motivation for multimedia data mining:

Tremendous benefits of traditional data mining have been proven for structured data. Now it's time for extending the mining techniques for unstructured, heterogeneous data.

1.1.3 Common Applications:

When multimedia is excavated for information, one of the most common uses for this evidence is to anticipate behavior patterns or trends. Information can be divided into classes as well, which allows different groups, such as men and women or Sundays and Mondays, to be analyzed separately. Data can be clustered, or grouped by logical relationship, which can help track consumer affinity for a certain brand over another.

Multimedia data mining for traffic video sequences – Example: Traffic camera footage to analyze traffic flow. This would come in handy while planning new streets, expanding existing streets, or diverting traffic. The same can be used by the Government organizations and city planners to help traffic flow more smoothly and quickly.

Multimedia Data Mining in Digital Libraries — The Digital library retrieves,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. Thus, in the process of conversion of the multimedia files in the libraries, the data mining techniques are popular.

Application in medical analysis -- Application of Data Mining Techniques for Medical Image Classification Media Production and Broadcasting – Proliferation of radio stations and TV channels makes broadcasting companies to search for more resourcefulmethodologies for creating programs and monitoring their content.

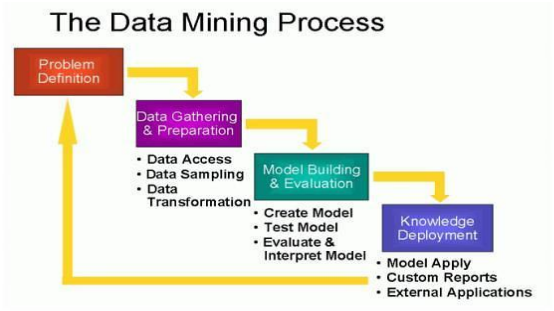
1.14 Multimedia databases: They include video, images, and audio and text media. They can be stored on extended object-relational or object-oriented databases, or simply on a file system.

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

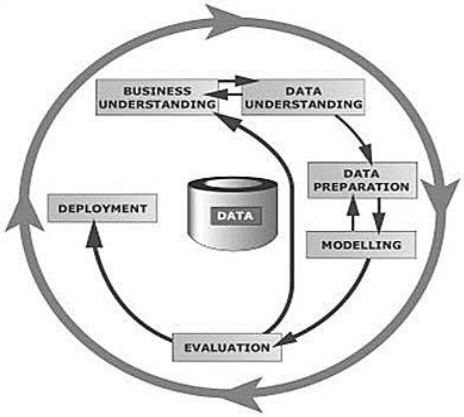
documents. These documents can be text, audio, video, raw data, and even applications.

2. Data Mining and Data Warehousing and Structured and Unstructured Data

2.1Data mining (the analysis step of the "Knowledge Discovery in Databases" process, or KDD),an interdisciplinary subfield of computer science, is the computational process of discovering patterns in large data sets involving methods at the intersection of artificial intelligence, machine learning, statistics, and database systems. The overall goal of the data mining process is to extract information from a data set and transform it into an understandable structure for further use. Aside from the raw analysis step, it involves database and data management aspects, data pre-processing, model and inference considerati ons, interestingness metrics, complexity considerations, post-processing of discovered structures, visualization, and online updating. The folowing figure shows us data mining



The data mining process involves a series of steps to define a business problem, gather and prepare the data, build and evaluate mining models, and apply the models and disseminate the new information.



2.2Data Warehousing:

In computing, a **data warehouse** (**DW**, **DWH**), or an **enterprise data warehouse** (**EDW**), is a database used for reporting and data analysis. Integrating data from one or more disparate sources creates a central repository of data, a data warehouse (DW). Data warehouses store current and historical data and are used for creating trending reports for senior management reporting such as annual and quarterly comparisons.

The data stored in the warehouse is uploaded from the operational systems (such as marketing, sales, etc., shown in the figure to the right). The data may pass through an operational for additional operations before it is used in the DW for reporting.

The typical extract-transform-load (ETL)-based data warehouse uses staging, data integration, and access layers to house its key functions. The staging layer or staging database stores raw data extracted from each of the disparate source data systems. The integration layer integrates the disparate data sets by transforming the data from the staging layer often storing this transformed data in an operational data store (ODS) database. The integrated data are then moved to yet another database, often called the data warehouse database, where the data is arranged into hierarchical groups often called dimensions and into facts and aggregate facts. The combination of facts and dimensions is sometimes called a star schema. The access layer helps users retrieve data.

2.3.Structured data

Data that resides in a fixed field within a record or file is called structured data. This includes data contained in relational databases and spreadsheets.

Structured data first depends on creating a data model – a model of the types of business data that will be recorded and how they will be stored, processed and accessed. This includes defining what fields of data will be stored and how that data will be stored: data type (numeric, currency, alphabetic, name, date, address) and any restrictions on the data input (number of characters; restricted to certain terms such as Mr., Ms. or Dr.; M or F).

Structured data has the advantage of being easily entered, stored, queried and analyzed. At one time, because of the high cost and performance limitations of storage, memory and processing, relational databases and spreadsheets using structured data were the only way to effectively manage data. Anything that couldn't fit into a tightly organized structure would have to be stored on paper in a filing cabinet.

2.4.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. 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 a multimedia data mining system. The first architecture includes the following. Extract data or metadata from the unstructured database. Store the extracted data in structured database and apply data mining tools on the structured database [8]. This is illustrated in figure 3.1.

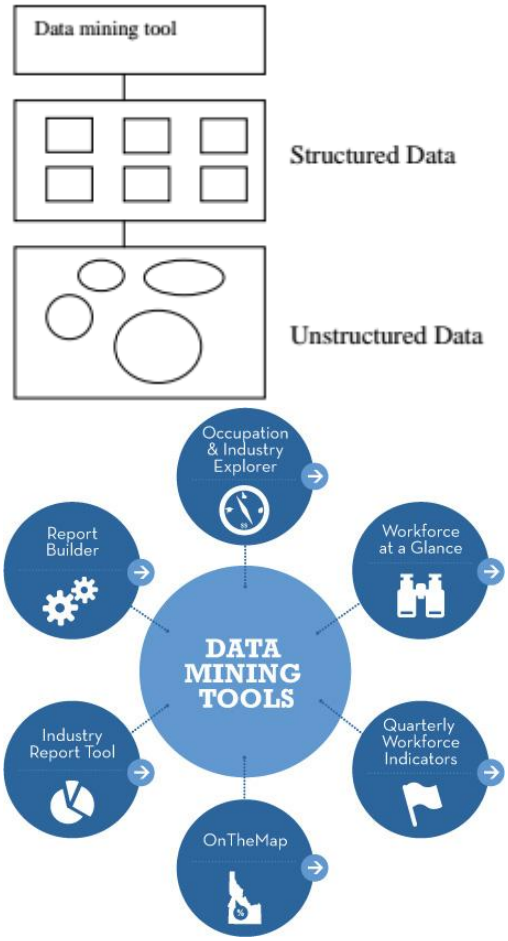


Fig 3.1

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 the 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

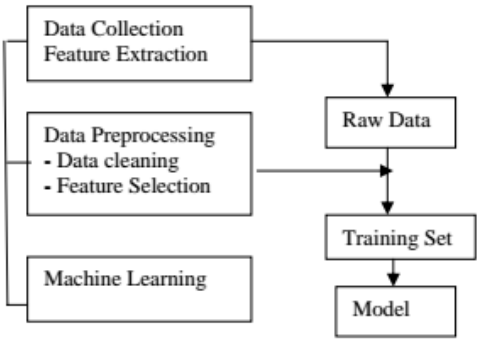


Figure 3.2: Multimedia mining process

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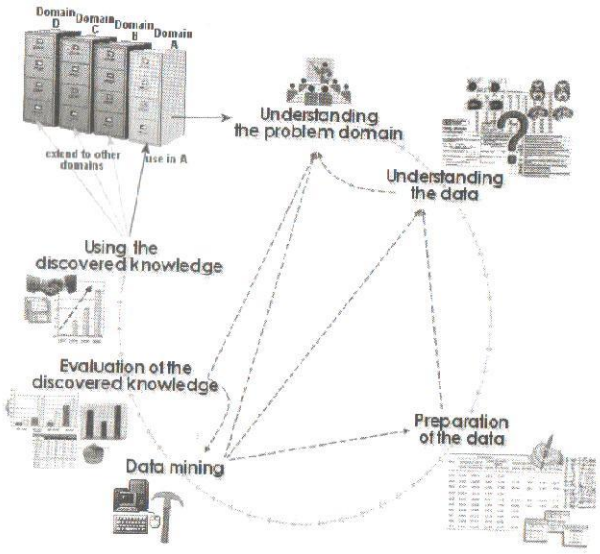
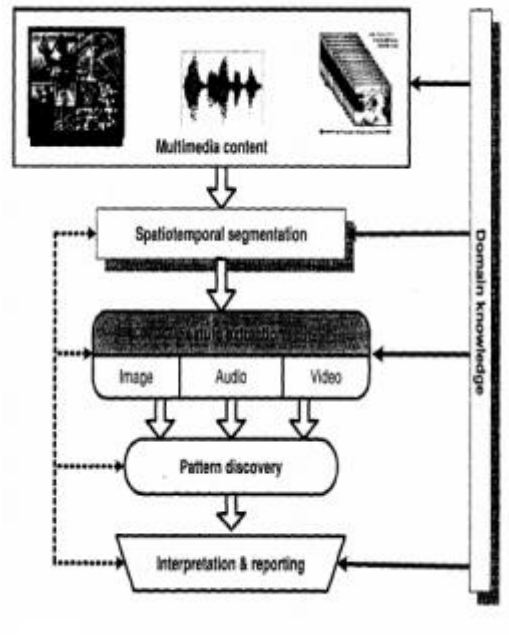
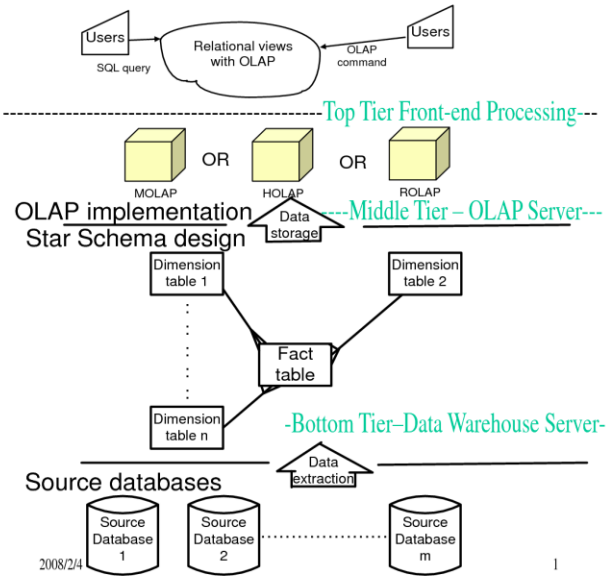


For many systems, this stage is still primarily conducted by domain experts. The product of data pre-processing is the training set. Given a training set, a learning model has to be chosen to learn from it. It must be mentioned that the steps of multimedia mining are often iterative. The analyst can also jump back and forth between major tasks in order to improve the results. Figure 3.3 presents the architecture of applying multimedia mining in different multimedia types.

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 relevant prior knowledge entirely before mining.



Architecture of Three Tier Data Warehouse



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 that are 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 the 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.

4. ISSUES IN MULTIMEDIA DATA MINING

Before multimedia data mining develops into a conventional, mature and trusted discipline, many 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. 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. The objective of multi-dimensional analysis is to gain an 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.

6. APPROACHES TO MULTIMEDIA DATAMINING

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 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 abstraction in the features, lower is the scope for ad hoc queries.

7. TECHNIQUES OF MDM

7.1 Multimedia Data Mining Process Using Classification Rules:

In this approach, main focus is on discovering the semantic structures. We use the classification rule approaches to perform data mining process because this approach only induces absolutely accurate rules. Examples of this work are:

1. The Hidden Markov Model

2. Detection of soccer goal shots using decision tree

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 unsupervised learning data mining technique. In unsupervised classification, the problem is to group a given collection of unlabeled multimedia files into meaningful clusters according to the multimedia content without Apriority knowledge. Recent works in this area are: 1. Unsupervised neural nets & staff organizing maps 2. Incremental clustering at various resolutions, using Haar Wavelet transforms and K- means

7.3 Multimedia Data Mining Process Using Association Rules:

For discovering interesting relations between variables in large databases, the Association rule learning is a popular and well researched method. There are different types of associations which are association between image content and non-image content features. Some early examples are:

1. Image classification method by using multiple level association rules based on image objects.

2. A multirelational extension to FP-tree algorithm to accomplish association rule mining task effectively

7.4 Multimedia Data Mining Through Statistical Modeling:

In this approach, a collection of images is used to build models for joint distribution of probabilities that link image features and keywords. An early example of this work is: 1. a simple occurrence model to establish links between words and partitioned image regions.

8. APPLICATIONS OF MULTIMEDIA DATA MINING

8.1. DATA MINING FOR SAFETY APPLICATIONS:

Different types of privacy problems have been considered by researchers. We will point out the various problems and the solutions projected.

8.1.1. **Problem:** Privacy contraventions that consequence due to data mining: In this case the way out is Privacy protecting data mining, that is, we perform data mining and give out the results without enlightening the data values used to perform data mining.

8.1.2.Problem: Privacy contraventions that result due to the Inference problem. Note that Inference is the procedure of realizing sensitive data details from the lawful answers received to user inquiries. The solution to this problem is Privacy Constraint Processing.

8.1.3.Problem: Privacy contravention due to un-encrypted data: the solution to this problem is to make use of Encryption at different levels.

8.1.4.Problem: Privacy contravention due to poor system design. Here the way out is to build up methodology for designing privacy-enhanced systems. Below we will observe the ways out projected for both privacy constraint/policy processing and for privacy preserving data mining. Privacy limitation or policy processing research was carried out by [8] and is footed on some of her prior research on security restriction processing. Instance of privacy restrictions include the following.

8.1.5.Simple Constraint: an aspect of a document is private. Content footed constraint: If document holds information about X, then it is private.

8.1.6.Association-based Constraint: Two or more documents used together are private; individually each document is public.

8.1.7. **Free constraint**: After X is freed, Y becomes private. The way out projected is to augment a database system with a privacy checker for constraint processing. During the inquiry process, the constraints are checked and only the public information is freed unless certainly the user is approved to obtain the private information. Our approach also contains processing constraints during the database update and design operations.

8.2. Customer Insight:

It includes collecting and summarizing information about customer‘s opinions, products or services, customers’ complains, customer‘s preferences, and the level of customer‘s satisfaction of products or services. Many companies have help desks or call centers that accept telephone calls from the customers. The audio data serve as an input for data mining to pursue the following goals:

- Topic detection
- Resource assignment
- Evaluation of quality of service

8.3. Surveillance:

Surveillance consists of collecting, analyzing, and summarizing audio, video, or audiovisual information about a particular area, such as battlefields, forests, agricultural areas, highways, parking lots, buildings, workshops, malls, retail stores, offices, homes, etc. [10], which are associated with intelligence, security, and law enforcement and the major uses of this technique are:

8.4. Mobility Prediction for Delay Reduction in WLAN using Location Tracking and Data Mining

Prediction of mobile path of a mobile node is of great importance since it reduces the handoff delays incurred during the handoff procedure. The proposed system is called Predictive Mobility Management scheme. We track the movement of mobile nodes by location tracking and data mining. In location tracking, we continuously monitor the movement of mobile node. The movement of mobile nodes can be predicted by the direction of movement of mobile nodes and previous path history which can be obtained by data mining techniques. The data mining technique is used to search the path history of mobile node and the technique uses this information to predict the future movement of mobile node. NG pruning scheme can be used for prediction along with location tracking. In NG pruning, we will exclude scanning of access points which are not reachable. Thus the scanning delay can be minimized to a large extent. Using the prediction scheme, we can minimize the delays during handoff, track a mobile node etc. When a node reaches out of range area, data sending to the node are directed to the AP which was selected by prediction where the node is going to get connected.

8.5. COMPLEX EVENT PROCESSING AND DATA MINING FOR SMART CITIES

Complex Event Processing (CEP) is emerging as a new paradigm for continuous processing of streaming data in order to detect relevant information and provide support for timely reactions. The main role of a CEP engine is to detect the occurrence of event patterns on the incoming streaming data. However, the problem of discovering the event patterns, although strongly related to the data mining field, has not been studied from the perspective of CEP applications

8.6. An application of data mining to fruit and vegetable sample identifying using Gas Chromatography-Mass Spectrometry

One of the uses of Gas Chromatography-Mass Spectrometry (GC-MS) is in the detection of pesticide residue in fruit and vegetables. In a high throughput laboratory, there exists a possibility of sample swaps or mislabeling, as once a sample has been pre-processed to be injected into the GC-MS analyzer, it is no longer distinguished by eye. Possible consequences of such mistakes can be the destruction of large amounts of actually safe procedure or pesticide-contaminated produce reaching the consumer. For the purpose of food safety and traceability, it can also be extremely voluble to know the source (country of origin) of the food products. This can help uncover fraudulent attempts of trying to sell food originating from countries deemed unsafe

8.7. Future directions

There are several future opportunities in the area of large-scale retrieval and mining that are worthy of attention from the multimedia community:

8.7.1 Many technical issues are yet to be addressed when managing large multimedia collections, for example, obtaining accurate annotations, efficient indexing of visual features, best possible creation of large-scale benchmark collections, and organizing these annotations.

8.7.2 Most state-of-the-art, machine-learning algorithms, such as nonlinear kernel support vector machines, kernel logistic regression, and k-means, can't be easily extended to large collections because their computational complexities are quadratic or even cubic with the size of the training set.

8.7.3 User interface, visualization, and interaction patterns will become more complicated with large quantities of data.

8.7.4 Distributed- and cloud-computing platforms as well as parallel machine-learning and data-mining algorithms will become necessary to make large-scale multimedia analysis run at practical speeds.

8.7.5 The availability of large-scale data might change the way we address the longstanding challenges in multimedia retrieval and mining, which could potentially lead to unexpected breakthroughs.

9. CONCLUSION

This paper proposes a survey of multimedia data mining. The key idea is to provide review of MDM, which is an active and growing area of research. While the majority of the work has been devoted to the development of data mining methodologies to deal with the specific issues of multimedia data, several applications of multimedia data mining have been investigated. Many of the recent MDM applications are focused on traffic monitoring and video surveillance, possibly due to increased attention to homeland security. In the coming years, we expect the MDM applications to grow especially in areas of entertainment and medicine. Almost all of the MDM efforts hitherto have been with the centralized data mining algorithms; however, this is expected to change as more and more multimedia content is searched and accessed through peers. The MDM is an active and growing area of research.

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