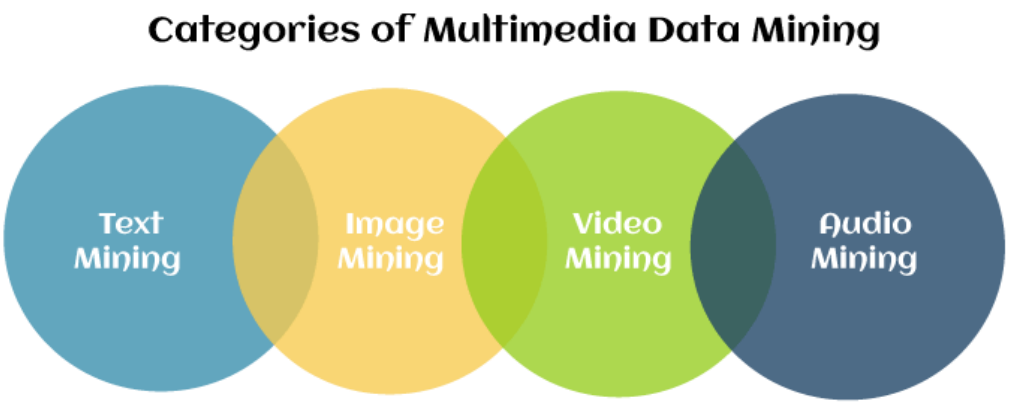
**Mining Complex Data Objects:**

Mining complex data objects refers to the process of extracting meaningful patterns, information, and insights from datasets that contain intricate and multi-dimensional data structures. These data objects can be anything from text documents and images to graphs, time series, or any other form of structured or unstructured data. The goal is to discover hidden knowledge and relationships within these complex data objects. Here are some common techniques and considerations for mining complex data objects:

1. **Text Mining:** Analyzing unstructured text data to extract information, sentiment, or patterns. Techniques include natural language processing (NLP), topic modeling, and sentiment analysis.
2. **Image and Video Analysis:** Analyzing image and video data to recognize patterns, objects, faces, or anomalies. Convolutional neural networks (CNNs) are often used for image classification and object detection.
3. **Graph Mining:** Analyzing data structured as graphs, such as social networks, transportation networks, or knowledge graphs. Techniques include graph algorithms, community detection, and link prediction.
4. **Time Series Analysis:** Analyzing data with a temporal component, such as financial data, sensor readings, or stock prices. Time series analysis methods include autoregressive models, moving averages, and spectral analysis.
5. **Spatial Data Analysis:** Dealing with data that has a geographic or spatial component, like GIS data. Spatial data mining involves techniques for clustering, classification, and spatial pattern recognition.
6. **Multi-modal Data Mining:** Integrating and mining data from multiple sources, which could include text, images, and numerical data. Fusion techniques aim to extract meaningful information from different modalities.
7. **Feature Engineering:** Preprocessing and transforming data to create relevant features for mining. This often involves dimensionality reduction techniques like Principal Component Analysis (PCA) or t-SNE.
8. **Machine Learning Algorithms:** Utilizing various machine learning algorithms such as decision trees, support vector machines, and deep learning models to discover patterns within the complex data objects.
9. **Data Visualization:** Creating visual representations of complex data objects to aid in pattern discovery. Tools like scatter plots, heatmaps, and network graphs can be helpful.
10. **Anomaly Detection:** Identifying outliers or anomalies within complex data objects. Anomalies can represent errors or important insights.
11. **Pattern Recognition:** Recognizing recurring patterns or associations within the data objects. This is often achieved through unsupervised learning techniques like clustering and association rule mining.
12. **Deep Learning:** Utilizing deep neural networks for tasks like image classification, natural language processing, and generative modeling.
13. **Domain Knowledge:** Incorporating domain-specific knowledge into the mining process to guide feature selection, model design, and interpretation of result

**Multimedia Database**

Multimedia mining refers to analyzing a large amount of multimedia information to extract patterns based on their statistical relationships. Multimedia data mining is classified into two broad categories: static and dynamic media. **Static media** contains text (digital library, creating SMS and MMS) and images (photos and medical images). **Dynamic media** contains Audio (music and MP3 sounds) and Video (movies). The below image shows the categories of multimedia data mining.



**1. Text Mining**

Text is the foremost general medium for the proper exchange of information. Text Mining evaluates a huge amount of usual language text and detects exact patterns to find useful information. Text Mining also referred to as text data mining, is used to find meaningful information from unstructured texts from various sources.

**2. Image Mining**

Image mining systems can discover meaningful information or image patterns from a huge collection of images. Image mining determines how low-level pixel representation consists of a raw image or image sequence that can be handled to recognize high-level spatial objects and relationships. It includes digital image processing, image understanding, database, AI, etc.

**3. Video Mining**

Video mining is unsubstantiated to find interesting patterns from many video data; multimedia data is video data such as text, image, metadata, visuals and audio. It is commonly used in security and surveillance, entertainment, medicine, sports and education programs. The processing is indexing, automatic segmentation, content-based retrieval, classification and detecting triggers.

**4. Audio Mining**

Audio mining plays an important role in multimedia applications, is a technique by which the content of an audio signal can be automatically searched, analyzed and rotten with wavelet transformation. It is generally used in automatic speech recognition, where the analysis efforts to find any speech within the audio. Band energy, frequency centroid, zero-crossing rate, pitch period and bandwidth are often used for audio processing.

**Application of Multimedia Mining**

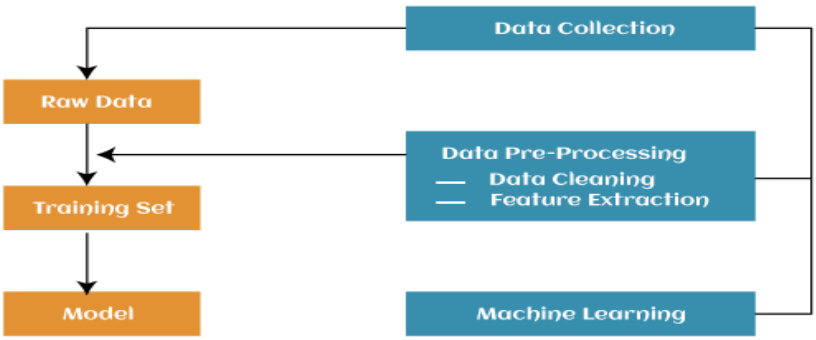
There are different kinds of applications of multimedia data mining, some of which are as follows:


- **Digital Library:** The collection of digital data is stored and maintained in a digital library, which is essential to convert different digital data formats into text, images, video, audio, etc.
- **Traffic Video Sequences:** To determine important but previously unidentified knowledge from the traffic video sequences, detailed analysis and mining are to be performed based on vehicle identification, traffic flow, and queue temporal relations of the vehicle at an intersection. This provides an economic approach for regular traffic monitoring processes.
- **Medical Analysis:** Multimedia mining is primarily used in the medical field, particularly for analyzing medical images. Various data mining techniques are used for image classification. Examples, Automatic 3D delineation of highly aggressive brain tumours, Automatic localization and identification of vertebrae in 3D CT scans, MRI Scans, ECG and X-Ray.
- **Customer Perception:** It contains details about customers' opinions, products or services, customers complaints, customers preferences, and the level of customer satisfaction with products or services, which are collected together. The audio data serve as topic detection, resource assignment and evaluation of the quality of services. Many companies have call centres that receive telephone calls from customers.

- **Media Making and Broadcasting:** Radio stations and TV channels create broadcasting companies, and multimedia mining can be applied to monitor their content to search for more efficient approaches and improve their quality.
- **Surveillance system:** It consists of collecting, analyzing, summarizing audio, video or audiovisual information about specific areas like government organizations, multi-national companies, shopping malls, banks, forests, agricultural areas and, highways etc. The main use of this technology in the field of security; hence it can be utilized by military, police and private companies since they provide security services.

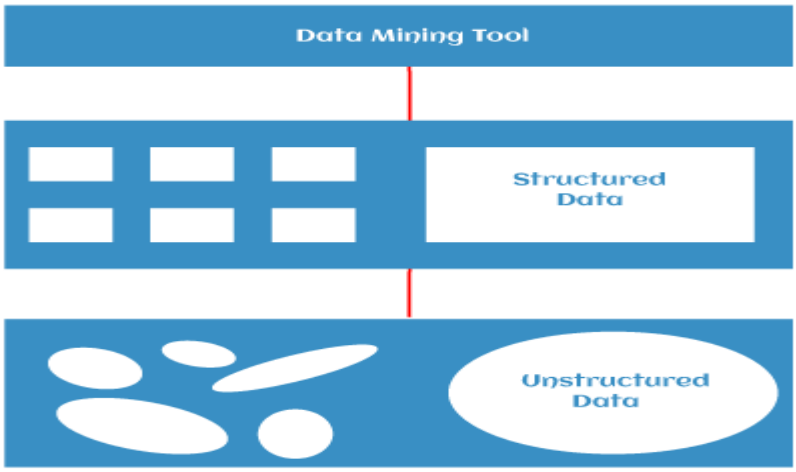
**Process of Multimedia Data Mining**

The below image shows the present architecture, which includes the types of the multimedia mining process. Data Collection is the initial stage of the learning system; Pre-processing is to extract significant features from raw data. It includes data cleaning, transformation, normalization, feature extraction, etc. Learning can be direct if informative types can be recognized at preprocessing stage. The complete process depends extremely on the nature of raw data and the difficulty field. The product of preprocessing is the training set. A learning model must be selected for the specified training set to learn from it and make the multimedia model more constant.




Multimedia Mining Process

**Converting Un-structured data to structured data:** Data resides in a fixed field within a record or file is called structured data, and these data are stored in sequential form. Structured data has been easily entered, stored, queried and analyzed. Unstructured data is bitstream, for example, pixel representation for an image, audio, video and character representation for text. These files may have an internal structure, but they are still considered "unstructured" because their data does not fit neatly in a database. For example, images and videos of different objects have some similarities - each represents an interpretation of a building without a clear structure.

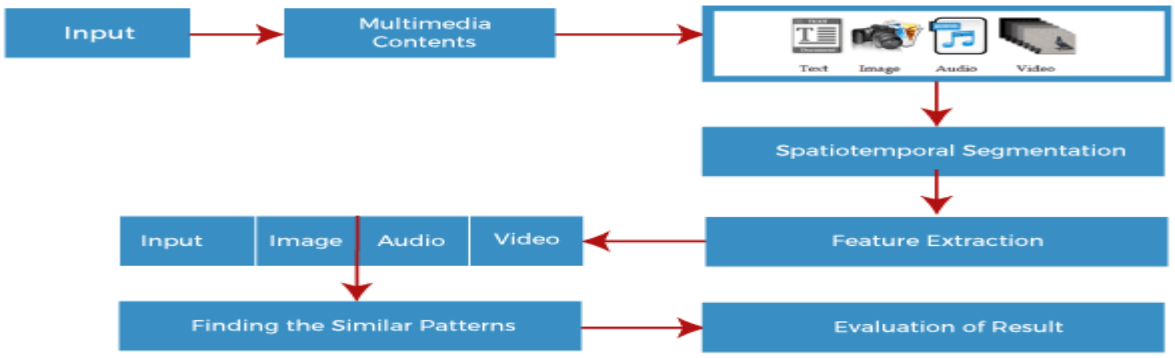



Unstructured Data to Structured Data Conversion

Current data mining tools operate on structured data, which resides in a huge volume of the relational database, while data in multimedia databases are semi-structured or unstructured. Hence, the semi-structured or unstructured multimedia data is converted into structured one, and then the current data mining tools are used to extract the knowledge. The sequence or time element is different between unstructured and structured data mining. The architecture of converting unstructured data to structured data and which is used for extracting information from the unstructured database, is shown in the above image. Then data mining tools are applied to the stored structured databases.

**Architecture for Multimedia Data Mining**

Multimedia mining architecture is given in the below image. The architecture has several components. Important components are Input, Multimedia Content, Spatiotemporal Segmentation, Feature Extraction, Finding similar Patterns, and Evaluation of Results.




Multimedia Data mining Architecture

1. **The input** stage comprises a multimedia database used to find the patterns and perform the data mining.
2. **Multimedia Content** is the data selection stage that requires the user to select the databases, subset of fields, or data for data mining.
3. **Spatio-temporal segmentation** is nothing but moving objects in image sequences in the videos, and it is useful for object segmentation.
4. **Feature extraction** is the preprocessing step that involves integrating data from various sources and making choices regarding characterizing or coding certain data fields to serve when inputs to the pattern-finding stage. Such representation of choices is required because certain fields could include data at various levels and are not considered for finding a similar pattern stage. In MDM, the preprocessing stage is significant since the unstructured nature of multimedia records.
5. **Finding a similar pattern** stage is the heart of the whole data mining process. The hidden patterns and trends in the data are basically uncovered in this stage. Some approaches to finding similar pattern stages contain association, classification, clustering, regression, time-series analysis and visualization.
6. **Evaluation of Results** is a data mining process used to evaluate the results, and this is important to determine whether the prior stage must be revisited or not. This stage consists of reporting and using the extracted knowledge to produce new actions, products, services, or marketing strategies.

**Models for Multimedia Mining**

The models which are used to perform multimedia data are very important in mining. Commonly four different multimedia mining models have been used. These are classification, association rule, clustering and statistical modelling.


1. **Classification:** Classification is a technique for multimedia data analysis that can learn from every property of a specified set of multimedia. It is divided into a predefined class label to achieve the purpose of classification. Classification is the process of constructing data into categories for its better effective and efficient use; it creates a function that well-planned data item into one of many predefined classes by inputting a training data set and building a model of the class attribute based on the rest of the attributes. Decision tree classification has a perceptive nature that the users conceptual model without loss of exactness. Hidden Markov Model is used to classify multimedia data such as images and videos as indoor-outdoor games.
2. **Association Rule:** Association Rule is one of the most important data mining techniques that help find relations between data items in huge databases. There are two types of associations in multimedia mining: image content and non-image content features. Mining the frequently occurring patterns between different images becomes mining the repeated patterns in a set of transactions. Multi-relational association rule mining displays multiple reports for the same image. In image classification also, multiple-level association rule techniques are used.
3. **Clustering:** Cluster analysis divides the data objects into multiple groups or clusters. Cluster analysis combines all objects based on their groups. In multimedia mining, the clustering technique can be applied to group similar images, objects, sounds, videos and texts. Clustering algorithms can be divided into several methods: hierarchical methods, density-based methods, grid-based methods, model-based methods, k-means algorithms, and graph-based models.
4. **Statistical Modeling:** Statistical mining models regulate the statistical validity of test parameters and have been used to test hypotheses, undertake correlation studies, and transform and make data for further analysis. This is used to establish links between words and partitioned image regions to form a simple co-occurrence model.

Issues in Multimedia Mining

Major Issues in multimedia data mining contains content-based retrieval, similarity search, dimensional analysis, classification, prediction analysis and mining associations in multimedia data.

**1. Content-based retrieval and Similarity search**

Content-based retrieval in multimedia is a stimulating problem since multimedia data is required for detailed analysis from pixel values. We considered two main families of multimedia retrieval systems, i.e. similarity search in multimedia data.

- **Description-based retrieval system** creates indices and object retrieval based on image descriptions, such as keywords, captions, size, and creation time.
- **Content-based retrieval system** supports image content retrieval, for example, colour histogram, texture, shape, objects, and wavelet transform.
- **Use of content-based retrieval system:** Visual features index images and promote object retrieval based on feature similarity; it is very desirable in various applications. These applications include diagnosis, weather prediction, TV production and internet search engines for pictures and e-commerce.

**2. Multidimensional Analysis**

To perform multidimensional analysis of large multimedia databases, multimedia data cubes may be designed and constructed similarly to traditional data cubes from relational data. A multimedia data cube has several dimensions. For example, the size of the image or video in bytes; the width and height of the frames, creating two dimensions, the date on which image or video was created or last modified, the format type of the image or video, frame sequence duration in seconds, Internet domain of pages referencing the image or video, the keywords like a colour dimension and edge orientation dimension. A multimedia data cube can have additional dimensions and measures for multimedia data, such as colour, texture, and shape.

The Multimedia data mining system prototype is MultiMediaMiner, the extension of the DBMiner system that handles multimedia data. The Image Excavator component of MultiMediaMiner uses image contextual information, like HTML tags on Web pages, to derive keywords. By navigating online directory structures, like Yahoo! directory, it is possible to build hierarchies of keywords mapped on the directories in which the image was found.

**3. Classification and Prediction Analysis**

Classification and predictive analysis has been used for mining multimedia data, particularly in scientific analysis like astronomy, seismology, and geoscientific analysis. Decision tree classification is an important method for reported image data mining applications. For example, consider the sky images, which astronomers have carefully classified as the training set. It can create models for recognizing galaxies, stars and further stellar objects based on properties like magnitudes, areas, intensity, image moments and orientation.

Image data mining classification and clustering are carefully connected to image analysis and scientific data mining. The image data are frequently in large volumes and need substantial processing power, such as parallel and distributed processing. Hence, many image analysis techniques and scientific data analysis methods could be applied to image data mining.

**4. Mining Associations in Multimedia**

Data Association rules involving multimedia objects have been mined in image and video databases. Three categories can be observed:

- Associations between image content and non-image content features
- Associations among image contents that are not related to spatial relationships
- Associations among image contents related to spatial relationships

First, an image contains multiple objects, each with various features such as colour, shape, texture, keyword, and spatial locations, so that many possible associations can be made. Second, a picture containing multiple repeated objects is essential in image analysis. The recurrence of similar objects should not be ignored in association analysis. Third, to find the associations between the spatial relationships and multimedia images can be used to discover object associations and correlations. With the associations between multimedia objects, we can treat every image as a transaction and find commonly occurring patterns among different images.