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MPEG-7 Context, Objectives and Technical Roadmap

0. Abstract

An incommensurable amount of audiovisual information is becoming available in digital form, in digital archives, on the World Wide Web, in broadcast datastreams and in personal and professional databases, and this amount is only growing. The value of information often depends on how easy it can be found, retrieved, accessed and filtered and managed. In spite of the fact that users have increasing access to these resources, identifying and managing them efficiently is becoming more difficult, because of the sheer volume. This applies to professional as well as end users. The question of identifying and managing content is not just restricted to database retrieval applications such as digital libraries, but extends to areas like broadcast channel selection, multimedia editing, and multimedia directory services.
The new MPEG-7 standard, formally called "Multimedia Content Description Interface", will provide a rich set of standardized tools to describe multimedia content. Both human users and automatic systems that process audiovisual information are within the scope of MPEG-7.

The active people in MPEG-7 represent broadcasters, electronics manufacturers, content creators and managers, publishers and intellectual property rights managers, telecommunication service providers and academia.

MPEG, the Moving Picture Experts Group, has set the successful MPEG-1 and MPEG-2 standards in 1992 and 1995, respectively. These standards have enabled the production of widely adopted commercial products, such as CD-interactive, digital audio broadcasting, digital television, and many video-on-demand trials and commercial services. MPEG-4 (Version 1 was finalised in 1998) is the first real multimedia representation standard, allowing interactivity and a combination of natural and synthetic material, coded in the form of objects. It models audiovisual data as a composition of these objects.

This document gives the reasons why MPEG-7 is being defined, and explains, at a high level, what the standard will look like. Note that MPEG-7 is far from ready yet, and that this document gives the current status; the standard will evolve further, to be finalized mid 2001. However, it will reach a fairly stable form already in fall 2000.

1. Context

More and more audio-visual information is available, from many sources around the world. The information may be represented in various forms of media, such as still pictures, graphics, 3D models, audio, speech, video. Audio-visual information plays an important role in our society, be it recorded in such media as film or magnetic tape or originating, in real time, from some audio or visual sensors and be it analogue or, increasingly, digital. While audio and visual information used to be consumed directly by the human being, there is an increasing number of cases where the audio-visual information is created, exchanged, retrieved, and re-used by computational systems. This may be the case for such scenarios as image understanding (surveillance, intelligent vision, smart cameras, etc.) and media conversion (speech to text, picture to speech, speech to picture, etc.). Other scenarios are information retrieval (quickly and efficiently searching for various types of multimedia documents of interest to the user) and filtering in a stream of audio-visual content description (to receive only those multimedia data items which satisfy the user's preferences). For example, a code in a television program triggers a suitably programmed VCR to record that program, or an image sensor triggers an alarm when a certain visual event happens. Automatic transcoding may be performed from a string of characters to audible information or a search may be performed in a stream of audio or video data. In all these examples, the audio-visual information has been suitably "encoded" to enable a device or a computer code to take some action.

Audio-visual sources will play an increasingly pervasive role in our lives, and there will be a growing need to have these sources processed further. This makes it necessary to develop forms of audio-visual information representation that go beyond the simple waveform or sample-based, compression-based (such as MPEG-1 and MPEG-2) or even objects-based (such as MPEG-4) representations. Forms of representation that allow some degree of interpretation of the information's meaning are necessary. These forms can be passed onto, or accessed by, a device or a computer code. In the examples given above an image sensor may produce visual data not in the form of PCM samples (pixels values) but in the form of objects with associated physical measures and time information. These could then be stored and processed to verify if certain programmed conditions are met. A video recording device could receive descriptions of the audio-visual information associated to a program that would enable it to record, for example, only news with the exclusion of sport. Products from a company could be described in such a way that a machine

could respond to unstructured queries from customers making inquiries.

MPEG-7 will be standard for describing the multimedia content data that will support these operational requirements. The requirements apply, in principle, to both real-time and non real-time as well as push and pull applications. MPEG will not standardize or evaluate applications. MPEG may, however, use applications for understanding the requirements and evaluation of technology. It must be made clear that the requirements in this document are derived from analyzing a wide range of potential applications that could use MPEG-7 descriptions. MPEG-7 is not aimed at any one application in particular; rather, the elements that MPEG-7 standardizes shall support as broad a range of applications as possible.

2. MPEG-7 Objectives

In October 1996, MPEG started a new work item to provide a solution to the questions described above. The new member of the MPEG family, called "Multimedia Content Description Interface" (in short 'MPEG-7'), will extend the limited capabilities of proprietary solutions in identifying content that exist today, notably by including more data types. In other words: MPEG-7 will specify a standard set of **Descriptors** that can be used to describe various types of multimedia information. MPEG-7 will also specify pre-defined structures of Descriptors and their relationships, as well as ways to define one's own structures. These structures are called **Description Schemes**. Defining new Description Schemes is done using a special language, the **Description Definition Language** (DDL), which is also a part of the standard. (See also 3 *"What is the Scope of the Standard"*). The description (i.e. a set of instantiated Description Schemes) shall be associated with the content itself, e.g. to allow fast and efficient searching for material of a user's interest. Lastly, MPEG-7 will include **coded representations** of a description, for instance for efficient storage, or fast access.

AV material that has MPEG-7 data associated with it, may include: still pictures, graphics, 3D models, audio, speech, video, and information about how these elements are combined in a multimedia presentation ('scenarios', composition information). Special cases of these general data types may include facial expressions and personal characteristics.

MPEG-7, like the other members of the MPEG family, is a standard representation of audio-visual information satisfying particular requirements. The MPEG-7 standard builds on other (standard) representations such as analogue, PCM, MPEG-1, -2 and -4. One functionality of the MPEG-7 standard is to provide references to suitable portions of them. For example, perhaps a shape descriptor used in MPEG-4 is useful in an MPEG-7 context as well, and the same may apply to motion vector fields used in MPEG-1 and MPEG-2.
MPEG-7 descriptors do, however, not depend on the ways the described content is coded or stored. It is possible to create an MPEG-7 description of an analogue movie or of a picture that is printed on paper. Even though the MPEG-7 description does not depend on the (coded) representation of the material, the standard in a way builds on MPEG-4, which provides the means to encode audio-visual material as objects having certain relations in time (synchronisation) and space (on the screen for video, or in the room for audio). If the material is encoded using MPEG-4, it will be possible to attach descriptions to elements (objects) *within* the scene, such as audio and visual objects. MPEG-7 will allow different granularity in its descriptions, offering the possibility to have different levels of discrimination.

Because the descriptive features must be meaningful in the context of the application, they will be different for different user domains and different applications.

This implies that the same material can be described using different types of features, tuned to the area of application. To take the example of visual material: a lower abstraction level would be a description of e.g. shape, size, texture, colour, movement (trajectory) and position ('where in the scene can the object be found?). And for audio: key, mood, tempo, tempo changes, position in sound space. The highest level would give semantic information: 'This is a scene with a barking brown dog on the left and a blue ball that falls down on the right, with the sound of passing cars in the background.' All these descriptions are of course coded in an efficient way - efficient for search that is. Intermediate levels of abstraction may also exist.

The level of abstraction is related to the way the features can be extracted: many low-level features can be extracted in fully automatic ways, whereas high level features need (much) more human interaction.

Next to having a description of the content, it may also be required to include other types of information about the multimedia data:

- *The form* - An example of the form is the coding scheme used (e.g. JPEG, MPEG-2), or the overall data size. This information helps determining whether the material can be 'read' by the user.
- *Conditions for accessing the material* - This could include intellectual property rights information, and price;
- *Classification* - This could include parental rating, and content classification into a number of pre-defined categories;
- *Links to other relevant material* - The information may help the user speeding up the search.
- *The context* - In the case of recorded non-fiction content, it is very important to know the occasion of the recording (e.g. Olympic Games 1996, final of 200 meter hurdles, men)

In many cases, it will be desirable to use textual information for the descriptions. Care will be taken, however, that the usefulness of the descriptions is as independent from the language area as possible. A very clear example where text comes in handy is in giving names of authors, film, places.

MPEG-7 data may be physically located with the associated AV material, in the same data stream or on the same storage system, but the descriptions could also live somewhere else on the globe. When the content and its descriptions are not co-located, mechanisms that link AV material and their MPEG-7 descriptions are needed; these links will have to work in both directions.

3. Scope of the Standard

MPEG-7 will address applications that can be stored (on-line or off-line) or streamed (e.g. broadcast, push models on the Internet), and can operate in both real-time and non real-time environments. A 'real-time environment' in this context means that the description is generated while the content is being captured.

Figure 1 below shows a highly abstract block diagram of a possible MPEG-7 processing chain, included here to explain the scope of the MPEG-7 standard. This chain includes feature extraction (analysis), the description itself, and the search engine (application). To fully exploit the possibilities of MPEG-7 descriptions, automatic extraction of features (or 'descriptors') will be extremely useful. It is also clear that automatic extraction is not always possible, however. As was noted above, the higher the level of abstraction, the more difficult automatic extraction is, and interactive extraction tools will be of good use. However useful they are, neither automatic nor semi-automatic feature extraction algorithms will be inside the scope of the standard. The main reason is that their standardisation is not required to allow

interoperability, while leaving space for industry competition. Another reason not to standardise analysis is to allow making good use of the expected improvements in these technical areas.
Also the search engines will not be specified within the scope of MPEG-7; again this is not necessary, and here too, competition will produce the best results.

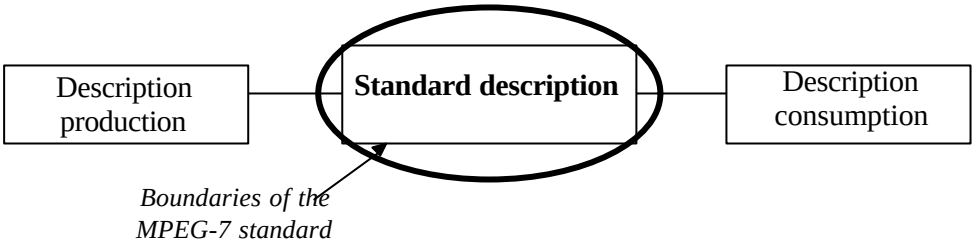

Figure 1: Scope of MPEG-7

To provide a better understanding of the terminology introduced in Section 1, i.e. Descriptor, Description Scheme, and DDL, please refer to Figures 2 and 3.

Figure 2 shows the extensibility of the above concepts. Furthermore, it indicates that the DDL provides the mechanism to build a Description Scheme which in turn forms the basis for the generation of a Description (see also Figure 3).

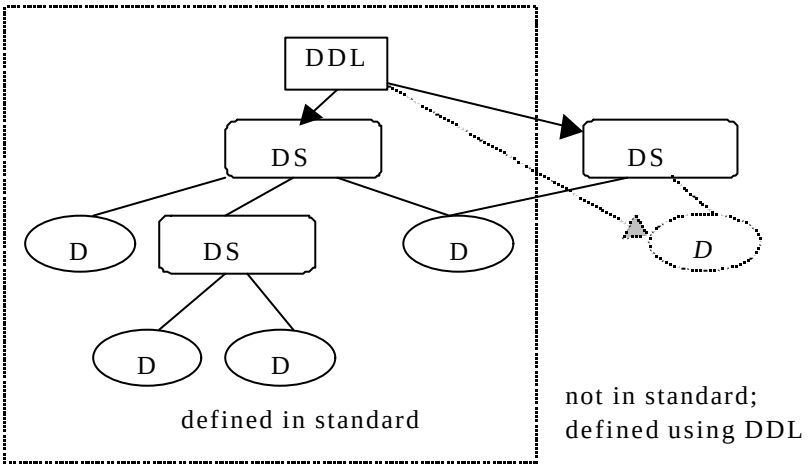

Figure 2: A graphical view of the relation between the different MPEG7 elements.

Figure 3 explains a hypothetical MPEG-7 chain in practice. The circular boxes depict tools that are doing things, such as encoding or decoding, whereas the square boxes represent static elements, such as a description. The dotted boxes in the figure encompass the normative elements of the MPEG-7 standard.

Note: There can be other streams from content to user; these are not depicted here. Furthermore, it is understood that there might be cases where a binary efficient representation of the description is not needed, and a textual representation would suffice. Thus, the use for the encoder and decoder is optional.

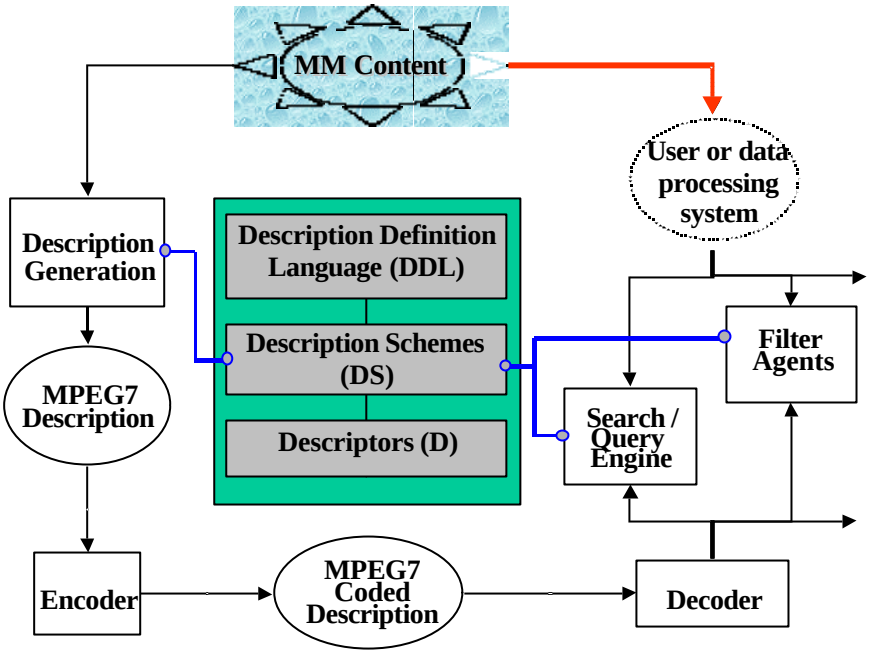

Figure 3: An abstract representation of possible applications using MPEG-7.

The emphasis of MPEG-7 will be the provision of novel solutions for audio-visual content description. Thus, addressing text-only documents will not be among the goals of MPEG-7. However, audio-visual content may include or refer to text in addition to its audio-visual information. MPEG-7 will therefore consider existing solutions developed by other standardisation organisations for text only documents and support them as appropriate.

Besides the descriptors themselves, the database structure plays a crucial role in the final retrieval's performance. To allow the desired fast judgement about whether the material is of interest, the indexing information will have to be structured, e.g. in a hierarchical or associative way.

More detailed descriptions of requirements can be found in the 'MPEG-7 Requirements Document' [1].

4. Areas of Interest

There are many applications and application domains which will benefit from the MPEG-7 standard. A few application examples are:

- Digital libraries (image catalogue, musical dictionary,…)
- Multimedia directory services (e.g. yellow pages)
- Broadcast media selection (radio channel, TV channel,…)
- Multimedia editing (personalised electronic news service, media authoring)

The potential applications are spread over the following application domains:

- Education,
- Journalism (e.g. searching speeches of a certain politician using his name, his voice or his face),
- Tourist information,
- Cultural services (history museums, art galleries, etc.),
- Entertainment (e.g. searching a game, karaoke),
- Investigation services (human characteristics recognition, forensics),
- Geographical information systems,

- Remote sensing (cartography, ecology, natural resources management, etc.),
- Surveillance (traffic control, surface transportation, non-destructive testing in hostile environments, etc.),
- Bio-medical applications,
- Shopping (e.g. searching for clothes that you like),
- Architecture, real estate, and interior design,
- Social (e.g. dating services), and
- Film, Video and Radio archives.

The way MPEG-7 data will be used to answer user queries is outside the scope of the standard. In principle, any type of AV material may be retrieved by means of any type of query material. This means, for example, that video material may be queried using video, music, speech, etc. It is to the search engine to match the query data and the MPEG-7 AV description. A few query examples are:

1. *Music*
Play a few notes on a keyboard and get in return a list of musical pieces containing (or close to) the required tune or images somehow matching the notes, e.g. in terms of emotions.

2. *Graphics*
Draw a few lines on a screen and get in return a set of images containing similar graphics, logos, ideograms,...

3. *Image*
Define objects, including colour patches or textures and get in return examples among which you select the interesting objects to compose your image.

4. *Movement*
On a given set of objects, describe movements and relations between objects and get in return a list of animations fulfilling the described temporal and spatial relations.

5. *Scenario*
On a given content, describe actions and get a list of scenarios where similar actions happen.

5. *Voice*
Using an excerpt of Pavarotti's voice, and getting a list of Pavarotti's records, video clips where Pavarotti is singing or video clips where Pavarotti is present.

More detailed descriptions of applications can be found in the 'MPEG-7 Applications Document' [2].

5. Method of Work and Work Plan

The method of development is comparable to that of the previous MPEG standards. MPEG work is usually carried out in three stages: definition, competition, and collaboration. In the definition phase, the scope, objectives and requirements for MPEG-7 were defined. In the competitive stage, participants worked on their technology by themselves. The end of this stage was marked by the MPEG-7 Evaluation following an open Call for Proposals (CfP) [5]. The Call asked for relevant technology fitting the requirements. In answer to the Call, all interested parties, no matter whether they participate or have participated in MPEG, were invited to submitted their technology to MPEG. Some 60 parties submitted, in total, almost 400 proposals, after which MPEG made a fair expert comparison between these submissions. Selected elements of different proposals will be incorporated into a common model (the eXperimentation

Model, or XM) during the collaborative phase of the standard. The goal is building the best possible model, which is in essence a draft of the standard itself. During the collaborative phase, the XM is updated and improved in an iterative fashion, until MPEG-7 reaches the Committee Draft (CD) stage, after several versions of the Working Draft. Improvements to the XM are made through Core Experiments (CEs). CEs are defined to test the existing tools against new contributions and proposals, within the framework of the XM, according to well-defined test conditions and criteria. Finally, those parts of the XM (or of the Working Draft) that correspond to the normative elements of MPEG-7 will be standardized.

A detailed description of the evaluation process can be found in the "MPEG-7 Evaluation Document" [3] The available audio-video material for these tests is described in the "Description of MPEG-7 Content Set" [6],its distribution and relevant licensing issues are outlined in the documents "Distribution of MPEG-7 Content Set" [7] and "Licensing Agreement for the MPEG-7 Content Set" [8]. The test phase of the XM is described in the "MPEG-7 PPD Document" [4].

The preliminary work plan for MPEG-7 foresees:

Call for Proposals	October 1998
Evaluation	February 1999
First version of Working Draft	December1999
Committee Draft	October 2000
Final Committee Draft	February2001
Draft International Standard	July 2001
International Standard	September 2001

6. MPEG-7 Terminology

1. Data

Definition

Data is audio-visual information that will be described using MPEG-7, regardless of storage, coding, display, transmission, medium, or technology.

Notes

This definition is intended to be sufficiently broad to encompass graphics, still images, video, film, music, speech, sounds, text and any other relevant AV medium.

Examples

Examples for MPEG-7 data are an MPEG-4 stream, a video tape, a CD containing music, sound or speech, a picture printed on paper, and an interactive multimedia installation on the web.

2. Feature

Definition

A Feature is a distinctive characteristic of the data which signifies something to somebody.

Notes

Features themselves cannot be compared without a meaningful feature representation (descriptor) and its instantiation (descriptor value) for a given data set.

Examples

Some examples are: color of an image, pitch of a speech segment, rhythm of an audio segment, camera motion in a video, style of a video, the title of a movie, the actors in a movie etc.

3. Descriptor

Definition

A Descriptor (D) is a representation of a Feature. A Descriptor defines the syntax and the semantics of the Feature representation.

Notes

A descriptor allows an evaluation of the corresponding feature via the descriptor value. It is possible to have several descriptors representing a single feature, i.e. to address different relevant requirements.

Examples

For example for the color feature, possible descriptors are: the color histogram, the average of the frequency components, the motion field, the text of the title, etc. More examples of Features and their associated Descriptors are provided in Table 1.

4. Descriptor Value

Definition

A Descriptor Value is an instantiation of a Descriptor for a given data set (or subset thereof).

Notes

Descriptor Values are combined via the mechanism of a Description Scheme (see point 5) to form a Description (see point 6).

Examples

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5. Description Scheme

Definition

A Description Scheme (DS) specifies the structure and semantics of the relationships between its components, which may be both Descriptors and Description Schemes.

Notes

The distinction between a DS and a D is, that a D contains only basic data types, as provided by the DDL (see point 8), and does not refer to another D or (sub)DS.

Examples

A movie, temporally structured as scenes and shots, including some textual descriptors at the scene level, and color, motion and some audio descriptors at the shot level.

6. Description

Definition

A Description consists of a DS (structure) and the set of Descriptor Values (instantiations) that describe the Data.

Notes

Depending on the completeness of the set of Descriptor Values, the DS may be fully or partially instantiated. Whether or not the DS is actually present in the Description depends on technical solutions still to be provided.

Examples

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7. Coded Description

Definition

A Coded Description is a Description that has been encoded to fulfil relevant requirements such as compression efficiency, error resilience, random access, etc.

Notes

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Examples

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8. Description Definition Language

Definition

The Description Definition Language (DDL) is a language that allows the creation of new Description Schemes and, possibly, Descriptors. It also allows the extension and modification of existing Description Schemes.

Notes

It is not yet clear to which extend the DDL will allow the creation of new descriptors.

Examples

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7. Frequently Asked Questions

1. What is MPEG-7?

MPEG-7 will be a standardised description of various types of multimedia information. This description will be associated with the content itself, to allow fast and efficient searching for material that is of interest to the user. MPEG-7 is formally called 'Multimedia Content Description Interface'.

The standard does not comprise the (automatic) extraction of descriptions/features. Nor does it specify the search engine (or any other program) that can make use of the description.

2. From whom or where did the demand for MPEG-7 come?

The demand logically follows the increasing availability of digital audio-visual content. MPEG members recognised this demand, and initiated a new work item. The work on the definition of MPEG-7 has already started to attract new people to MPEG.

3. Why is MPEG-7 needed?

Nowadays, more and more audio-visual information is available, from many sources around the world. Also, there are people who want to use this audio-visual information for various purposes. However, before the information can be used, it must be located. At the same time, the increasing availability of potentially interesting material makes this search more difficult. This challenging situation led to the need of a solution to the problem of quickly and efficiently searching for various types of multimedia material interesting to the user. MPEG-7 wants to answer to this need, providing this solution.

4. Who is currently participating in the development of the MPEG-7 standard?

The people taking part in defining MPEG-7 represent broadcasters, equipment manufacturers, digital content creators and managers, transmission providers, publishers and intellectual property rights managers, as well as university researchers.

5. Where are you in the process of specifying the MPEG-7 standard?

We are in the collaborative phase of the standardisation process. This means that we have passed the Call for Proposals and the evaluation of the submissions to that CfP. We are

currently performing experiments (so-called Core Experiments) to continuously improve the technology on the table for standardization. This testing is carried out in a common environment, called the eXperimentation Model (XM). Experiments are carried out in well-defined test conditions and according to pre-defined criteria. The goal is to develop the best possible standard.

6. Will MPEG-7 include audio or video content recognition?

The standardisation of audio-visual content recognition tools is beyond the scope of MPEG-7. Following its principle 'specifying the minimum for maximum usability, MPEG-7 will concentrate on standardising a representation that can be used for description. Development of audio-visual content recognition tools will be a task for industries which will build and sell MPEG-7 enabled products.

In developing the standard, however, MPEG might build some coding tools, just as it did with the predecessors of MPEG-7, namely MPEG-1, -2 and -4. Also for these standards, coding tools were built for research purposes, but they did not become part of the standard itself.

7. Will MPEG-7 support audio or video content retrieval?

In the same way that MPEG will not standardise the tools to generate the description, MPEG-7 will also not standardise the tools that use the description. It might however be necessary to address the interface between the description and the search engine.

8. What form will the "descriptions" of multimedia content in MPEG-7 take?

The words 'descriptions' or 'features' represent a rich concept, that can be related to several levels of abstraction. Descriptions vary according to the types of data. Furthermore, different types of descriptions are necessary for different purposes of the categorisation.

9. Will the standard allow automatic extraction of descriptions as well as manual entry?

The descriptions that conform to the MPEG-7 standard could be entered by hand, but they could also be automatically extracted. Some features can be best extracted automatically (colour, texture), but for some other features ('this scene contains three shoes and that music was recorded in 1995') this is very hard or even impossible.

10. A 'Call for Proposals', how does that work?

A Call for Proposals (CfP) asks for technology for inclusion in the standard. It is addressed at all interested parties, no matter whether they participate or have participated in MPEG.

MPEG work is usually carried out in two stages, a competitive and a collaborative one. In the competitive stage, participants work on their technology by themselves. In answer to the CfP, people submit their technology to MPEG, after which MPEG makes a fair comparison between the submissions. In MPEG-2 and -4 this was done using subjective tests and additional expert evaluation. How such evaluations will be carried out for MPEG-7 is not yet known, but this will be described in the CfP when it is published in 1998.

Based on the outcome of the evaluation, MPEG will decide which proposals to use for the collaborative stage. In this stage, members of the Experts Group work together on improving and expanding the standard under construction, building on the selected proposals.

Before the final CfP in November 1998, preliminary versions may be published. This is

comparable to what happened for MPEG-4.

11. What is the relationship between MPEG-7 and other MPEG activities?

MPEG-7 can be used independently of the other MPEG standards - the description might even be attached to an analog movie. The representation that is defined within MPEG-4, i.e. the representation of audio-visual data in terms of objects, is however very well suited to what will be built on the MPEG-7 standard. This representation is basic to the process of categorisation. In addition, MPEG-7 descriptions could be used to improve the functionality of previous MPEG standards.

12. If I want to get involved in MPEG-7, what do I need to know about the other MPEG standards?

In principle, knowledge about the other three MPEG standards is not required for taking part in the MPEG-7 work. However, since some of MPEG-7's tools may be close to those of MPEG-4, some knowledge about them could be useful.

13. If I want to know more about the other MPEG standards, where do I look?

You can start by taking a look at MPEG's home page (http://www.cselt.it/mpeg/) which contains many useful references, including more lists with "Frequently Asked Questions" about MPEG activities.

14. So what happened to MPEG-5 and -6? (And how about 3?)

MPEG-3 existed once upon a time, but its goal, enabling HDTV, could be accomplished using the tools of MPEG-2, and hence the work item was abandoned. So after 1,2 and 4, there was much speculation about the next number. Should it be 5 (the next) or 8 (creating an obvious binary pattern)? MPEG, however, decided not to follow either logical expansion of the sequence, but chose the number of 7 instead. So MPEG-5 and MPEG-6 are, just like MPEG-3, not defined.

15. When will MPEG-7 replace the existing MPEG-1 and MPEG-2 standards?

MPEG-7 will not replace MPEG-1 MPEG-2 or in fact MPEG-4 it is intended to provide complementary functionality to these other MPEG standards: representing information about the content, not the content itself ("the bits about the bits". This functionality is the standardisation of multimedia content descriptions.

17. If I want to know more about, be involved in, or give an input to the MPEG-7 development process, whom should I contact?

You can contact any of the people listed below with their email addresses and telephone numbers. To visit MPEG meetings you need to be on your national delegation, but the people listed below can explain how this works.

8. Contacts

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