A Brief Overview of Affective Multimedia Databases

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Abstract. *Multimedia documents such as videos, images, sounds and text inevitable stimulate emotional responses which can be measured. These documents are stored in dedicated affective databases along with descriptive metadata such as emotion and semantics. The landscape of multimedia databases for elicitation and estimation of emotions is very diverse. The databases are continuously employed in many areas such as psychology, psychiatry, neurosciences and cognitive sciences in studies of emotional responses, anxiety, stress, attention, cognitive states and in brain research. Their data models are also being increasingly used in computer science for sentiment analysis, multifaceted search in multimedia retrieval and automated recognition of emotions. Because of their growing relevance, it is important to compile a concise overview of the most important multimedia databases for stimulation and estimation of emotions. The aim of the paper is to help domain experts to find more easily the optimal database for their research, and others to quickly familiarize themselves with this area. The overview lists 24 most recent and frequently used affective multimedia databases, which jointly contain 126,805 emotionally-annotated multimedia documents, and describes their quintessential properties.*

Keywords. affective computing, multimedia, databases, emotion stimuli, emotion estimation

1 Introduction

Even though not immediately apparent all multimedia documents provoke emotional reactions of different intensities and polarities (Coan & Allen, 2007). Human-computer interfaces allow users to observe pictures, video clips, generated graphics, read text or listen to sounds, music and human voices which all, deliberately or inadvertently, modulate their emotional states (Brave & Nass, 2003). This spontaneous cognitive process has many practical applications in cognitive sciences, psychology and neuroscience (Frantzidis et al., 2010). Affective multimedia is also very important for various computer science domains such as affective computing and human-computer interaction (Palm & Glodek, 2013). Combined with sufficiently immersive and unobtrusive visualization hardware such as Head Mounted Display (HMD) or high-resolution television sets in low-interference ambient affective multimedia databases provide a simple, low-cost and efficient means to scientifically study emotional impact (Villani & Riva, 2012). Overall, the scope of emotion-related research is growing and, accordingly, the importance of these databases is steadily increasing.

Multimedia documents with annotated semantic and emotion content are stored in affective multimedia databases. Apart from digital objects these databases contain meta-data about their high-level semantics and statistically expected emotion that will be induced in a subject when exposed to a multimedia document. The semantics is annotated manually by researchers and emotions are estimated in controlled experiments with human subjects.

The paper provides a short overview of the most important contemporary affective multimedia databases containing video, general pictures, pictures of faces, audio and text. It is impossible to list all databases in a short format since new ones are continuously being developed. Further, many are either small or not publicly available and constructed for specific experiments.

2 Properties of affective multimedia databases

Contemporary affective multimedia databases are not relational databases or complex structures for massive storage of multimodal data. In fact, they are simple repositories of audio-visual multimedia documents such as pictures, sounds, text, videos etc. with described general semantics and emotion content. Two distinct features differentiate affective multimedia databases from other multimedia repositories: 1) purpose of multimedia documents and 2) emotion representation of multimedia documents. Multimedia documents in affective multimedia databases are explicitly aimed at inducing or stimulating emotions in

exposed subjects. As such they are usually referred to as stimuli. All multimedia documents (i.e. stimuli) in affective multimedia databases have specified semantic and emotional content. Sometimes they are accompanied with specific meta-data such as elicited psychological or neurological signals. Importantly, these databases are still very difficult to build, use and maintain (Horvat, Popović & Ćosić, 2013).

Affective multimedia databases are created by different groups of researchers and usually shared freely for scientific and educational purposes (Bradley & Lang, 2000). The databases are standardized which allows them to be used in a controllable and predictable manner (Horvat, Bogunović & Ćosić, 2014). With affective multimedia databases the process of emotion stimulation is not stochastic, unpredictable or singular but articulated, controlled and comparable to the scientifically established practices. An important consequence of the standardization is that the emotion elicitation effects can be measured, replicated and validated by different research teams. Before standardized affective multimedia databases have been developed researchers had to create unique stimuli sequences for each emotion experiment. Stimuli used in one laboratory were rarely used by other laboratories. Attempts at recreating the same experimental materials from descriptions in the literature were time-consuming, difficult and prone to errors. Therefore, the development of affective multimedia databases represents a significant improvement in the study of emotions, behaviour and cognition.

The most cited affective repository for emotion elicitation is The Pictures of Facial Affect (POFA) (Ekman & Friesen, 1975). The Nencki Affective Picture System (NAPS) (Marchewka et al., 2014) together with its domain expansions The Nencki Affective Picture System discrete emotional categories (NAPS BE) (Riegel et al., 2016) and The Erotic subset for the Nencki Affective Picture System (NAPS ERO) (Wierzba et al., 2015) are the newest large general repositories. Examples of typical stimuli from some of the datasets are shown in Fig. 1.

Figure 1. Exemplar visual stimuli from four repositories. From top to bottom and left to right: NAPS (Marchewka et al., 2014), The International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 2008), The Military Affective Picture System (MAPS) (Goodman, Katz & Dretsch, 2016), The NimStim Face Stimulus Set (Tottenham et al., 2009).

The following sections describe in more detail semantic and emotional models used in contemporary affective multimedia databases.

2.1 Semantic models

Affective multimedia databases have very simple semantic models. The stimuli are described with mutually unrelated keywords from unsupervised glossaries. Most often only a single keyword is used to describe a document. Moreover, lexical variations and synonyms are often used for description of similar concepts. Some databases organize documents in several semantic categories such as “people”, “objects”, “landscape”, “faces” etc. However, semantic relations between different concepts, and documents which they describe, are left broadly undefined. For example, in the IAPS a picture portraying an attack dog can be tagged as “dog”, “canine” and “hound”, “attack”, “attackdog” and “attack_dog”. Pictures displaying people are described with singulars and plurals such as “man” and “men” or “woman” and “women”. Natural language processing methods and more sophisticated knowledge representation schemes are necessary to improve information performance from affective multimedia databases (Horvat, Vuković & Car, 2016). Document retrieval is possible only with lexical relatedness measures since there are no criteria to calculate semantic similarity between concepts in query and document metadata descriptions (Horvat, Vuković & Car, 2016). More expressive and formal semantic models are not possible without modification of database multimedia descriptors and introduction of appropriate knowledge structures (Horvat, Bogunović & Ćosić, 2014; Horvat et al., 2009). As was already experimentally shown, the inadequate semantic descriptors result in three negative effects which impair stimuli retrieval: 1) low recall, 2) low precision and high recall or 3) vocabulary mismatch (Horvat, Bogunović & Ćosić, 2014; Horvat, Vuković & Car, 2016).

2.2 Emotion models

Documents in affective multimedia databases are described with at least one of the two emotion models: categorical and dimensional (Peter & Herbon, 2006). The dimensional model, which is also called Circumplex model of affect (Posner, Russell & Peterson, 2005) or Pleasure Arousal Dominance model (PAD) (Mehrabian, 1996), is founded on theories of emotion which propose that affective meaning can be well characterized by a small number of dimensions.

Dimensions are chosen on their ability to statistically characterize subjective emotional ratings with the least number of dimensions possible (Bradley & Lang, 1994). These dimensions generally include one bipolar or two unipolar dimensions that represent positivity and negativity and have been labelled in various ways, such as valence or pleasure. Moreover, usually included is a dimension that captures intensity, arousal, or energy level. In computer models these dimensions are described with two orthogonal vectors called valence and arousal which form a two-dimensional cartesian space. The length of the vectors, i.e. dimensional emotion values or normative ratings, are real numbers between 1.0 and 9.0. Such model is simple and easy to represent in digital systems.

In contrast to the dimensional theories, categorical theories claim that the dimensional models, particularly those using only two dimensions, do not accurately reflect the neural systems underlying emotional responses. Instead, supporters of these theories propose that there are many emotions that are universal across cultures and have an evolutionary and biological basis (Ekman, 1992). Which discrete emotions are included in these theories is a point of contention, as is the choice of which dimensions to include in the dimensional models. Most supporters of discrete emotion theories agree that six primary emotions exist: happiness, sadness, surprise, anger, fear and disgust. Basic emotions can be represented as areas inside the valence-arousal space. Their exact shape and location are individually dependent and have a developmental trajectory throughout a person's lifetime (Posner, Russell & Peterson, 2005). Dimensional and categorical theories of affect can both effectively describe emotion in digital systems but are not mutually exclusive. Some repositories already incorporate both theories of emotion – per example (Riegel et al., 2016). Annotations according to both theories are useful because they provide a more complete characterization of stimuli affect.

It has been experimentally proven that visual stimuli from the IAPS produce different responses in skin conductance, startle reflex, breathing and heart rate depending (Bradley et al., 2001a; Bradley et al., 2001b; Kukolja et al., 2014). Relationship of EEG signals to emotion phenomena is being intensively investigated (Wu et al., 2010). Recently new open-access toolboxes are being developed to simplify deep analysis of physiological time-series such as ECG and EEG (Jovic et al., 2016).

3 Catalogue of affective multimedia databases

The landscape of affective multimedia databases is very diverse. Mainly the databases are pictorial and small. A substantial number of databases are used rarely while some larger databases are employed frequently. To avoid negative effects of habituation emotion should be induced with visually and auditory different stimuli, but with the same or compatible semantics (Coan & Allen, 2007). Because of this reason researchers often employ the largest affective multimedia databases which are adequately diverse. Smaller databases with fewer different stimuli are employed only for small-scale or domain research where the lack of stimuli variety is less important.

The catalogue of affective multimedia databases is in Table 1. Apart from the POFA (Ekman & Friesen, 1975), the most important affective picture repository is The International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 2008). Other significant databases are: The Geneva affective picture database (GAPED) (Dan-Glauser & Scherer, 2011), NAPS (Marchewka et al., 2014), NAPS BE (Riegel et al., 2016), NAPS ERO (Wierzba et al., 2015), as well as DIsgust-RelaTed-Images (DIRTI) database (Haberkamp et al., 2017), Set of Fear Inducing Pictures (SFIP) (Michałowski et al., 2017), MAPS (Goodman, Katz & Dretsch, 2016), Besançon Affective Picture Set-Adolescents (BAPS-Ado) (Szymanska et al., 2015), LIRIS-ACCEDE (Baveye et al., 2015), Geneva faces and voices (GEFAV) database (Ferdenzi et al., 2015), Child Affective Facial Expression Set (CAFE) (LoBue & Thrasher, 2014), Affectiva-MIT Facial Expression Dataset (AM-FED) (McDuff et al., 2013), Emotional Movie Database (EMDB) (Carvalho et al., 2012), DEAP: A Database for Emotion Analysis using Physiological Signals (Koelstra et al., 2012), NIMH Child Emotional Faces Picture Set (NIMH-ChEFS) (Egger et al., 2011), Radboud Faces Database (RaFD) (Langner et al., 2010), NimStim Face Stimulus Set (Tottenham et al., 2009), CAS-PEAL Large-Scale Chinese Face Database (Gao et al., 2008), International Affective Digitized Sounds (IADS) (Bradley & Lang, 2007a), Affective Norms for English Texts (ANET) (Bradley & Lang, 2007b), Karolinska Directed Emotional Faces (KDEF) (Lundqvist, Flykt & Öhman, 1998), Japanese Female Facial Expression (JAFFE) Database (Lyons et al., 1998) and, finally, Affective Norms for English Words (ANEW) (Bradley & Lang, 1999).

Altogether, there are 3 video databases (VID), 7 picture databases (PIC), 8 picture face databases (FAC), 1 video and face database (FAC VID), 1 video and sound face database (FAC VID SND), 2 with text (TXT) and 1 database only with sounds (SND). The stimuli are annotated with the discrete emotion model (DIS) or with the dimensional model (DIM), or both (DIM DIS). IAPS and IADS stimuli were originally annotated only with valence and arousal values but later emotion norms were also added (DIS*).

Table 1. The list of the most often used collections of audio-visual stimuli sorted from the newest to the oldest.

Name	Modality	Emotion	Stimuli No.	Published
DIRTI	PIC	DIM DIS	300	2017
NAPS/NAPS BE	PIC	DIM DIS	1,356	2014-2016
SFIP	PIC	DIM	1,400	2016
NAPS ERO	PIC	DIM	200	2015
MAPS	PIC	DIM	240	2015
BAPS-Ado	PIC	DIM DIS	93	2015
LIRIS-ACCEDE	VID	DIM	9,800	2015
GEFAV	FAC VID SND	DIS	111	2014
CAFÉ	FAC	DIS	1,192	2014
AM-FED	FAC VID	DIS	242	2013
EMDB	VID	DIM	52	2012
DEAP	VID	DIM	120	2012
GAPED	PIC	DIS	730	2011
NIMH-ChEFS	FAC	DIS	482	2011
RaFD	FAC	DIS	536	2010
NimStim	FAC	DIS	672	2009
CAS-PEAL	FAC	DIS	99,594	2008
IAPS	PAC	DIM DIS*	1,182	1997-2008
IADS	SND	DIM DIS*	111	1999-2007
ANET	TXT	DIM	60	1999-2007
KDEF	FAC	DIS	4,900	1998
JAFFE	FAC	DIS	213	1998
ANEW	TXT	DIM	3,109	1999
POFA	FAC	DIS	110	1976-1993

Some datasets had multiple revisions in the designated time frame. Annotations are explained in the text above. The newest repository is DIRTI being published in 2017, the largest is CAS-PEAL with 99,594 pictures of 1,040 individuals, and the most expressively annotated is NAPS/NAPS BE/NAPS ERO as single linked corpora. As can be seen facial expression databases, or face databases, are the most numerous modality among affective multimedia databases. they are employed in emotion elicitation, these databases are also often used in computer vision for face recognition and face detection. For a more detailed overview of these databases consult (Gao et al., 2008). The presented catalogue is not exhaustive, nevertheless it includes the most frequently referenced databases. Additional lists of affective multimedia databases which may be used for emotion estimation can be found in (Baveye et al., 2015; Zeng et al., 2009; Gao et al., 2008).

4 Conclusion

In this article we have presented a compact catalogue of affective multimedia databases. In total, 24 repositories were listed containing 126,805 documents of different modalities. The principal purpose of these databases is to provoke emotional reactions in a predictable manner. Their multimedia content is described with the dimensional or discrete emotion model, or sometimes both.

The wider field of affective multimedia databases research provides several interesting directions for investigation and development. Most importantly, these databases should be interlinked and become more practical through multifaceted queries combining semantics, emotion and other available metadata. Construction of new repositories must be facilitated, as well as creation of personalized stimuli sequences. Introduction of structured data sources has already shown promising results in document retrieval quality (Horvat, Grbin & Gledec, 2013). Knowledge discovery of integrated data could provide statistically significant indicators of hidden relationships between semantics and emotion (Horvat, Popović & Ćosić, 2012). Looking even further into the future, truly multimodal corpora containing haptic and olfactory stimuli are likely to be developed. Eventually, interactive virtual reality stimuli will become common-place.

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