

A State of the Art Review on Emotional Speech Databases

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Abstract

Thirty-two emotional speech databases are reviewed. Each database consists of a corpus of human speech pronounced under different emotional conditions. A basic description of each database and its applications is provided. The conclusion of this study is that automated emotion recognition on these databases cannot achieve a correct classification that exceeds 50% for the four basic emotions, i.e., twice as much as random selection. Second, natural emotions cannot be easily classified as simulated ones (i.e., acting) can be. Third, the most common emotions searched for in decreasing frequency of appearance are anger, sadness, happiness, fear, disgust, joy, surprise, and boredom.

Keywords

Speech Recognition, Speech Databases, Emotion Recognition, Interfaces (Emotions and personality), Situation Awareness Applications (Training).

1. Introduction

Emotion is an important factor in communication. For example, a simple text dictation that doesn't reveal any emotion, it does not convey adequately the semantics of the text. An emotion speech synthesizer could solve such a communication problem. Speech emotion recognition systems can be used by disabled people for communication, by actors for emotion speech consistency as well as for interactive TV, for constructing virtual teachers, in the study of human brain malfunctions, and the advanced design of speech coders. Until recently many voice synthesizers could not produce faithfully a human emotional speech. This results to an unnatural and unattractive speech. Nowadays, the major speech processing labs worldwide are trying to develop efficient algorithms for emotion speech synthesis as well as emotion speech recognition. To achieve such ambitious goals, the collection of emotional speech databases is a prerequisite. In this paper, thirty-two emotional speech databases are reviewed. In Section 2, a brief description of each database is provided. In Section 3, a discussion of the reviewed databases features is made. Finally, conclusions are drawn in Section 4.

2. Description of Speech Emotion Databases

This section briefly describes the thirty-two databases included in our comparative study per language used. Table 5 in the Appendix provides a complete listing of the databases and their features.

2.1. English speech emotion databases

Database 1. The database was recorded at the Faculty of Electrical Engineering and Computer Science, University of Maribor, Slovenia [1]. It contains emotional speech in six emotion categories, such as disgust, surprise, joy, fear, anger and sadness. Two neutral emotions were also included: fast loud and low soft. It is seen that the emotion categories are **compliant with MPEG-4** [2]. The database contains 186 utterances per emotion category.

Database 2. R. Cowie [31], [6], [32] constructed this database at the Queen's University of Belfast. The readers are 40 volunteers aged between 18 to 69 years. The subjects read 5 passages of 7-8 sentences written in an appropriate emotional tone and content for each emotional state. Each passage has strong relationship with the corresponded emotional state.

Database 3, Belfast Natural Database. R. Cowie and M. Schroder constructed this database at Queen's University [36]. Two kinds of recordings took place. One was recorded in studio and the other direct from TV programs. The clip length is taken to be quite long in order to reveal the development of emotion through time. The studio recordings consist of two parts. The first part contains conversations between students. The second part contains audio-visual recordings of interviews (one-to-one).

Database 4, Kids' Audio Speech Corpus NSF/ITR Reading Project. R. Cole and his assistants at the University of Colorado recorded database 4 [12]. The aim of the project was to collect sufficient audio and video data from kids in order to enable the development of auditory and visual recognition systems, which enable face-to-face conversational interaction with electronic teachers. Only 1000 out of 45000 utterances are emotion oriented.

Database 5, Emotional Prosody Speech and Transcripts. M. Liberman at the University of Pennsylvania constructed database 5 [13]. The database consists of 9 hours of speech data. It contains speech in 15 emotional categories. This database is distributed by the LDC [13].

Database 6 SUSAS. J. Hansen at the University of Colorado Boulder has constructed database SUSAS (Speech Under Simulated and Actual Stress) [13]. The database contains voice from 32 speakers with ages ranging from 22 to 76. In addition, four military helicopter pilots were recorded during the flight. Words from a vocabulary of 35 aircraft communication words make up the database.

Database 7. C. Pereira at Macquarie University constructed Database 7 [19]. The database consists of 40 sentences said by two actors in 5 emotional categories. There are 2 repetitions of these 40 utterances, thus creating 80 presentations. In the study, 31 normal hearing subjects rated all the utterances. The listeners rated each utterance on six Likert intensity scales (Mehrabian and Russel, 1974).

Database 8. M. Edgington at BT Labs, UK collected database 8 for training a voice synthesizer [11]. Thirteen raters-judges identified the emotions with 79.3% score rate. The database also includes the signal energy, syllabic duration, and the fundamental frequency of each phoneme.

Database 9. T. S. Polzin and A. H. Waibel at the Carnegie Mellon University constructed database [15]. The corpus was comprised of 291 word tokens per emotion per speaker. The sentence length varies from 2 to 12 words. These sentences are comprised of questions, statements, and orders. The database was evaluated from other people. The recognition of each emotion is 70%.

Database 10. V. Petrushin at the Center for Strategic Technology Research, Accenture constructed this database in order to train neural networks in speech recognition [25]. It is divided into two studies. The first study deals with a corpus of 700 short utterances expressed by 30 professional actors. In the second study, 56 telephone messages were recorded.

Database 11. R. Fernandez at MIT labs constructed emotional speech Database 11 [27]. The subjects were drivers who were asked to sum up two numbers while driving a car. The two independent variables in this experiment were the driving speed and the frequency at which the driver had to solve the math questions.

2.2 German speech emotion databases

Database 12, Verbmobil. The database was recorded at the University of Hamburg [38], [8]. The database contains voice from 58 native German speakers, (29 male, 29 female), while they were speaking to a “pretended” ASR system. From distance, a researcher (“a wizard”) controlled the ASR response, in such a way that the speaker believed that he was speaking to a machine. The above dialogues are named “Wizard-Of-Oz” dialogues. Prosodic properties of the emotion, such as syllable lengthening and word emphasis are also annotated.

Database 13, SmartKom Multimodal Corpus. It was constructed at the Institute for Phonetik and Oral Communication in Munich [38], [39]. The database consists of Wizard-Of-Oz dialogues (like Verbmobil database) in German and English. The database contains multiple audio channels and two video channels (face, body from side). The aim of the project was to build a gesture and voice recognition module for human-computer interfaces.

Database 14. W. F. Sendlmeier et al. at the Technical University of Berlin collected 14 [4], [34]. Each one of the ten professional actors expresses ten words and five sentences in all the emotional categories. The corpus was evaluated by 25 judges who classified each emotion with a score rate of 80%.

Database 15. K. Alter at the Max-Planck-Institute of Cognitive Neuroscience constructed database 15 [20]. Electroencephalogram (EEG) was also recorded. The aim of the project was to relate emotions, which are recognized from speech with a location in the human brain. A trained female fluent speaker was employed. Twenty subjects judged both the semantic content and the prosodic feature on a five-point scale.

Database 16. K. Scherer at the University of Geneva constructed this database [21]. The purpose of his study was to bring into light the differences in emotional speech perception between people from different countries. The sentences derived from an artificial language, which was constructed by a professional phonetician.

Database 17, Magdeburger Prosodie Korpus. B. Wendt and H. Scheich at Leibniz Institute of Neurobiology constructed the Magdeburger Prosodie Korpus [9]. The aim was to construct a brain map of emotions. The database contains also the word accentuation, word length, speed rate, abstraction/concreteness, categorizations, and phonetic minimal pairs.

Database 18. M. Schroeder recorded a database of diphones that can be used for emotional speech synthesis [16]. One male speaker of standard German produced a full German diphone set for each of three degrees of

vocal effort: “soft”, “modal”, and “loud”. Four experts verified the vocal effort, the pitch constancy, and the phonetic correctness.

Database 19. M. Schroeder has constructed database 19, which consists “affect bursts” [7]. His study shows that affect bursts, presented without context, can convey a clearly identifiable emotional meaning. Professionals selected the affect bursts from the German literature. Altogether, the database comprises about 80 different affect bursts. The database contains speech in 10 emotion categories.

2.3 Japanese speech emotion databases

Database 20. R. Nakatsu et al. at the ATR Laboratories constructed database 20 [37]. The database contains speech in 8 emotion categories. The project employed 100 native speakers (50 male and 50 female) and one professional radio speaker. The professional speaker was told to read 100 neutral words in 8 emotional manners. The ordinary speakers were asked to mimic the manner of the professional actor and say the same amount of words.

Database 21. Y. Niimi et al. at the Kyoto Institute of Technology developed database 21 [14]. It consists of VCVs (vowel consonant vowel) segments for each of the three emotion speech categories. These VCVs can generate any accent pattern of Japanese. These VCVs were collected from a corpus of 400 linguistic unbiased utterances. The utterances were analyzed to derive a guideline for designing VCV databases, and to derive an equation for each phoneme, which can predict its duration based on its surrounding phonemic and linguistic context. Twelve people judged the database and they recognized each emotion with a rate of 84%.

Database 22. A. Iida and N. Campbell at ATR Laboratories constructed database 22 [28]. The emotions are simulated but not exaggerated. The database consists of monologue texts collected from newspapers, the WWW, self-published autobiographies of disabled people, essays and columns. Some expressions typical to each emotion were inserted in appropriate places in order to enhance the expression of each target emotion.

2.4 Dutch emotion speech databases

Database 23, Groningen Database. It is constructed at the Psychology School at Groningen University in Netherlands and is distributed by ELRA [8]. It contains 20 hours of Dutch speech. The database is only partially oriented to emotion. An electroglottograph and an orthographic transcription are also included. The speakers are not actors and the emotions are forced rather than natural. The database consists of short texts, short sentences, digits, monosyllabic words, and long vowels.

Database 24. S. Mozziconacci collected database 24 in order to study the relationship between speed in speaking and emotion [17], [29]. The speech material used in the study consists of 315 utterances. Each of the three speakers reads five sentences, which have a semantically neutral content. Twenty-four judges evaluated the utterances and two intonation experts labeled.

2.5 Spanish emotion speech databases

Database 25, Spanish Emotional Speech database (SES). J. M. Montero and his assistants constructed database 25 [10]. Fifteen raters-judges identified each emotion with a score of 85%. The labeling of the database is semi-automatic. The corpus consists of 3 short passages (4-5 sentences), 15 short sentences, and 30 isolated words. All have neutral lexical, syntactical, and semantical meaning.

Database 26. I. Iriondo [26] at the University of R. L. of Barcelona recorded database 26. The speech was rated-judged by 1054 students during a perception test. From the 336 discourses, only 34 passed the perception test.

2.6 Danish emotion speech database

Database 27 DES. I. F. Engberg, T. Brondsted and A.V. Hansen at the Center for Person Kommunikation at Aalborg University recorded the Danish Emotional Speech database [3]. The construction of DES was a part of Voice Attitudes and Emotions in Speech Synthesis (VAESS) project. Twenty judges (native speakers from 18 to 58 year old) verified the emotions with a score rate of 67%.

2.7 Hebrew emotion speech database

Database 28. At the faculty of Holon Academic Institute of Technology at Israel, N. Amir et al. recorded emotional multi-modal speech database 28 [5]. The database consists of emotional speech, electromyogram of the corrugator (a muscle of the upper face which assists in expressing an emotion), heart rate, and galvanic resistance that is a sweat indicator.

2.8 Sweden emotion speech database

Database 29. A. Abelin et al. recorded database 29 [18]. Different nationality listeners classified the emotional utterances to an emotional state. The listener group consisted of 35 native Swedish speakers and 78 Swedish immigrants.

2.9 Chinese emotion speech database

Database 30. F. Yu et al. at the Microsoft Research China recorded database 30 [23]. It contains speech segments from Chinese teleplays. Four persons tagged the 2000 utterances. When two or more persons agreed in their tag, the utterance got their tag.

2.10 Russian emotion speech database

Database 31, RUSSian LANguage Affective speech (RUSSLANA). V. Makarova and V.A. Petrushin collected this database at the Meikai University in Japan [40]. The total of utterances is 3660 sentences from 61 (12 male) native Russian speakers age from 16 to 28. Features of speech like energy, pitch and formants curves are also included.

2.11 Multilingual emotion speech database

Database 32, Lost Luggage study. K. Scherer has recorded database 32 [24]. The recordings took place in Geneva International Airport. The subjects are 109 airline passengers waiting in vain for their luggage to arrive on the belt.

3. Discussion

3.1 Database purpose

An emotional speech database is collected for a variety of purposes. In the set of thirty databases, we found that most databases were used for automatic speech recognition and speech synthesis.

Purpose	Databases	Total number
Automatic emotion recognition with ASR applications	1, 2, 3, 5, 7, 9, 10, 11, 12, 13, 20, 24, 25, 26, 28, 30, 31, 32	18
Emotion speech synthesis	1, 2, 3, 5, 8, 14, 18, 19, 21, 22, 27	11
Emotion perception by human	7, 9, 13, 16, 21, 29, 32	7
Medical applications	5, 7, 15, 17	4
Speech and Stress	6, 11	2
Virtual teacher	4	1

Table 1: Database purpose

For several databases we know the correct recognition rate of emotions by humans. For example, for Database 8 this rate is 79%, whereas for Database 9 is 70%. Slightly higher correct recognition rates were reported for Databases 13 and 20. These rates were 80% and 84%, respectively. To derive the rates, groups of judges (usually 20-30 people) were employed. As indicated, a human can recognize correctly an emotion in speech with an average rate of 80%. Thus, it is difficult to build an automated emotion recognition system, which can classify emotions more accurately than 80%. As indicated by Cowie [36] a successful automatic classifier hits a correct classification rate of 50%, when the classification of four emotions is dealt with. If the emotion categories were four, a random classification would achieve a score of 25%. This observation was restated in Banse-Scherer [35], but for a larger number of emotions.

3.2 Most common emotions

The most common emotions, that can be found in the set of 32 databases reviewed, arranged in decreasing order of their frequency of appearance are summarized in Table 3. The most common recordings are anger, sadness, happiness, fear, disgust, surprise, boredom and joy. This is almost in agreement with Cowie and Cornelius [33], except for boredom. Boredom seems to be more popular than it was originally thought.

Emotion	Number of databases
Anger	26
Sadness	22
Happiness	13
Fear	13
Disgust	10
Joy	9
Surprise	6
Boredom	5
Stress	3
Contempt	2
Dissatisfaction	2
Shame, pride, worry, startle, elation, despair, humor, ...	1

Table 3: Emotion recorded in databases.

3.3 Simulated or natural emotions

Natural emotions cannot be easily classified by a human [27]. Since a human cannot classify easily natural emotions, it is difficult to expect that machines can offer a higher correct classification. In order to avoid complicated situations, the majority of the databases include forced (simulated) emotional speech. Professional actors, drama students or normal people express these emotional utterances. Extravagation from the actors during speech recording is usually prohibited. Table 4 indicates the types of speech emotion and their frequency of occurrence.

Type of Emotion	Occurrences	Database Index
Simulated	21	1, 5, 7, 8, 9, 14, 15, 16, 17, 18, 19, 20,21, 22, 23, 24, 25, 26, 27, 29, 31
Natural	8	2, 4, 12, 13, 28, 30, 11, 32
Half recordings natural, Half recordings simulated	2	6, 32
Semi-natural	1	3

Table 4: Natural and simulated speech occurrences.

4 Conclusions

From the comparative study of the thirty-two databases, we conclude that there is a need for establishing a protocol that will address the following issues:

- ❖ Collection parameters:
 - Simulated feelings by actors or drama students or
 - natural feelings by ordinary people
- ❖ Types of data
 - Speech
 - Video
 - Laryngograph
 - Myograms of the face
 - Heart Beat Rate
 - EEG
- ❖ Multiplicity of data: How many recording sessions exist in the database
- ❖ Data availability
- ❖ Objective methods of measuring the performance of the methods employed
- ❖ Subjective methods of conducting mean opinion scores

The aforementioned discussion provides a minimal list of specifications for recording any future database to be used for speech emotion recognition. We recommend the data to be distributed by organizations (like LDC or ELRA) under a reasonable fee so that the experiments reported in the literature could be repeated. This is not the case with the majority of the databases reviewed in this paper, whose terms of distribution are unclear.

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Appendix

Features of the thirty-two emotion speech databases reviewed.

#	Language	Author	Collector/Distributor	Subjects	Other	Tr/on	Feelings
1	Slovenian, French, Slovenian, English.	D. Ambrus	Univ. of Maribor, Slovenia	2 actors	LG	Yes	Sim/ted
2	English	R. & E./Cowie	Belfast Queen's Univ.	40 volunteers	-	Yes	Natural
3	English	R. & E./Cowie	Belfast Queen's Univ.	125 from TV	V	Yes	Semi-Nat
4	English	R. Cole	Univ. Colorado, CSLR	780 kids	V	Yes	Natural
5	English	M. Liberman	Univ. Pensylv., LDC	Actors	-	Yes	Sim/ted
6	American English	J. Hansen	Univ. Colorado, LDC	32 soldiers and students	-	Yes	Half-Half
7	English	C. Pereira	Univ. Macquire, Australia	2 actors	-	Yes	Sim/ted
8	English	M. Edgington	BT Labs, U.K.	1 male actor	LG	Yes	Sim/ted
9	English	T. Polzin, A. Waibel	Carnegie Mellon Univ.	5 drama students	LG	Yes	Sim/ted
10	English	V. Petrushin	Univ. of Indiana	30 native	-	Yes	Half-Half
11	English	R. Fernandez	MIT	4 drivers	-	Yes	Natural
12	German	K. Fisher	Univ. of Hamburg	58 native	-	70%	Natural
13	German	F. Schiel	Institute. for Phonetik and Oral Commun., Munich	45 native	V	Yes	Natural
14	German	W. Sendlemeier	Univ. of Berlin	10 actors	V, LG	Yes	Sim/ted
15	German	K. Alter	Max-Planck Institute	1 female	EEG	Yes	Sim/ted
16	German	K. R. Scherer	Univ. of Geneva	4 actors	-	Yes	Sim/ted
17	German	B. Wendt	Leibniz Institute	2 actors	-	Yes	Sim/ted
18	German	M. Schroeder	Univ. of Saarland	1 male	-	Yes	Sim/ted
19	German	M. Schroeder	Univ. of Saarland	6 native	-	Yes	Sim/ted
20	Japanese	R. Nakatsu	ATR Japan	100 native, 1 actor	-	Yes	Sim/ted
21	Japanese	Y. Niimi	Matsugasaki Univ., Kyoto	1 male	-	Yes	Sim/ted
22	Japanese	N. Campbell	ATR, Japan	2 native	-	Yes	Sim/ted
23	Dutch	A.M. Sulter	Univ. of Groningen, ELRA	238 native	LG	Yes	Sim/ted
24	Dutch	S. Mozziconacci	Univ. of Amsterdam	3 native	-	Yes	Sim/ted
25	Spanish	J. M. Montero	Univ. of Madrid	1 male actor	-	Yes	Sim/ted
26	Spanish	I. Iriondo	Univ. Barcelona	8 actors	-	Yes	Sim/ted
27	Danish	I. Engberg	Univ. Aalborg	4 actors	-	Yes	Sim/ted
28	Hebrew	N. Amir	Holon, Israel	40 students	LG,M,G,H	Yes	Natural
29	Sweden	A. Abelin	Univ. of Indiana	1 native	-	Yes	Sim/ted
30	Chinese	F. Yu	Microsoft, China	Native	-	Yes	Sim/ted
31	Russian	V. Makarova	Meikai Univ. /Japan	61 native	-	Yes	Sim/ted
32	Various	K. Scherer	Univ. of Geneva	109 passengers	V	No	Natural

Table 5. Tr/on: Transcription, LG:Laryngograph, M: Myogram of face, V: Video, G: Galvanic resistance, EEG: ElectroEncephaloGram, H: Heart Beat Rate, Sim/ted: Simulated.

#	Emotions	Material
1	Disgust, surprise, fear, anger sad, joy, 2 neutral	Words, numbers, sentences (affirmative, interrogative), paragraph
2	Anger, happy, sad, fear, neutral	5 passages written in appropriate emotional tone and content (x emotion x speaker)
3	Various	239 Clips (10-60 sec) from television, and real interviews
4	Not- exactly	Computer commands, Mathematics, words, Full digit sequences, Monologue
5	Hot anger, cold anger, panic-anxiety, despair, sadness, elation, happiness, interest, boredom, shame, pride, disgust, contempt	Numbers, months, dates
6	Stress, angry, question, fast, Lombard effect, soft, loud, slow	Special words (brake, left, slow, fast, right...) that used in army; 16.000 utterances
7	Happy, sad, 2 anger, neutral	80 sentences in each emotion per actor
8	Anger, fear, sad, boredom, happy, neutral	4 emotionally neutral sentences and 1 phrase in six emotional styles
9	Fear, happy, anger, sad	50 sentences x emotion x speaker
10	Fear, sad, anger, happy, neutral	700 short utterances and 56 telephone messages of 15-90 sec
11	Stress, Natural	Numbers
12	Mainly anger, dissatisfaction	58 dialogues last from 18 to 33 minutes
13	Mainly anger, dissatisfaction	90 dialogues of 4.5 minutes
14	Fear, anger, disgust, boredom, sad, joy, neutral	10 words and 5 sentences per emotion; total 1050 utterances
15	Happy, anger, neutral	148 sentences x emotion; 1776 sentences
16	Fear, anger, joy, sad, disgust	Sentences from artificial language
17	Fear, happy, sad, anger, disgust, neutral	3000 nouns and 1200 pseudo words
18	Soft, modal, loud	All diphones for all emotions
19	Admiration, threat, elation, relief, startle anger, disgust, boredom, contempt, worry, hot anger	80 affect bursts for all emotions
20	Anger, sad, happy, fear, surprise, disgust, playfulness	100 neutral words x emotion, total 80000 words
21	Anger, sad, joy	Vowel-Consonant-Vowel sequences from 400 utterances
22	Joy, anger, sad	72 monologue texts of 450 sentences each
23	Not exactly	Subjects read 2 short texts with many quoted sentences to elicit emotional speech
24	Fear, neutral, joy, boredom, anger, sad, indignation	Total 315 sentences of semantically neutral content
25	Sad, happy, anger, neutral	3 passages, 15 sentences, 30 words per emotion
26	Fear, joy, desire, fury, surprise, sad, disgust	2 texts x 3 emotion intensities per emotion; total 336 discourses
27	Anger, happy, sad, surprise	2 words, 9 sentences, 2 passages per emotion
28	Anger, fear, joy, sad, disgust	The subjects were told to recall an emotional situation of their life and speak about that
29	Fear, anger, joy, shy, disgust, sad, surprise, dominance	Sentences spoken in all emotional styles
30	Anger, happy, sad, neutral	Short audio clips from TV, 721 utterances
31	Surprise, happy, anger, sad, fear and neutral	10 sentences x emotion x speaker; total 3660 sentences
32	Anger, humor, indifference, stress, sad	Unobtrusive videotaping of passengers at lost luggage counter followed up by interviews

Table 5 continued.