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Opportunities given by biometrics in the field of neurodegenerative diseases: Face and Writing

Carlos M. TRAVIESO

Signals and Communications Department

Institute for Technological Development and Innovation in Communications IDETIC)

University of Las Palmas de Gran Canaria, SPAIN

ctravieso@dsc.ulpgc.es

Outline

- Introduction
- General Idea
- Expression Detection (ED) from facial images
- Use of handwritten information
- Fusion Approach from different sources
- Conclusions
- Acknowledgements

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Introduction (I)

- Technological advances have made possible the proliferation of equipment and latest technologies, making progresses.

- One of many new applications is the emotion detection, being the goal of this work.

Introduction (II)

- It can be used for various purposes, as the detection of possible symptoms of neurological diseases in humans

- This field of expression detection is developing in multiple applications and researches, which gives an idea of the importance acquired and the multitude of applications.

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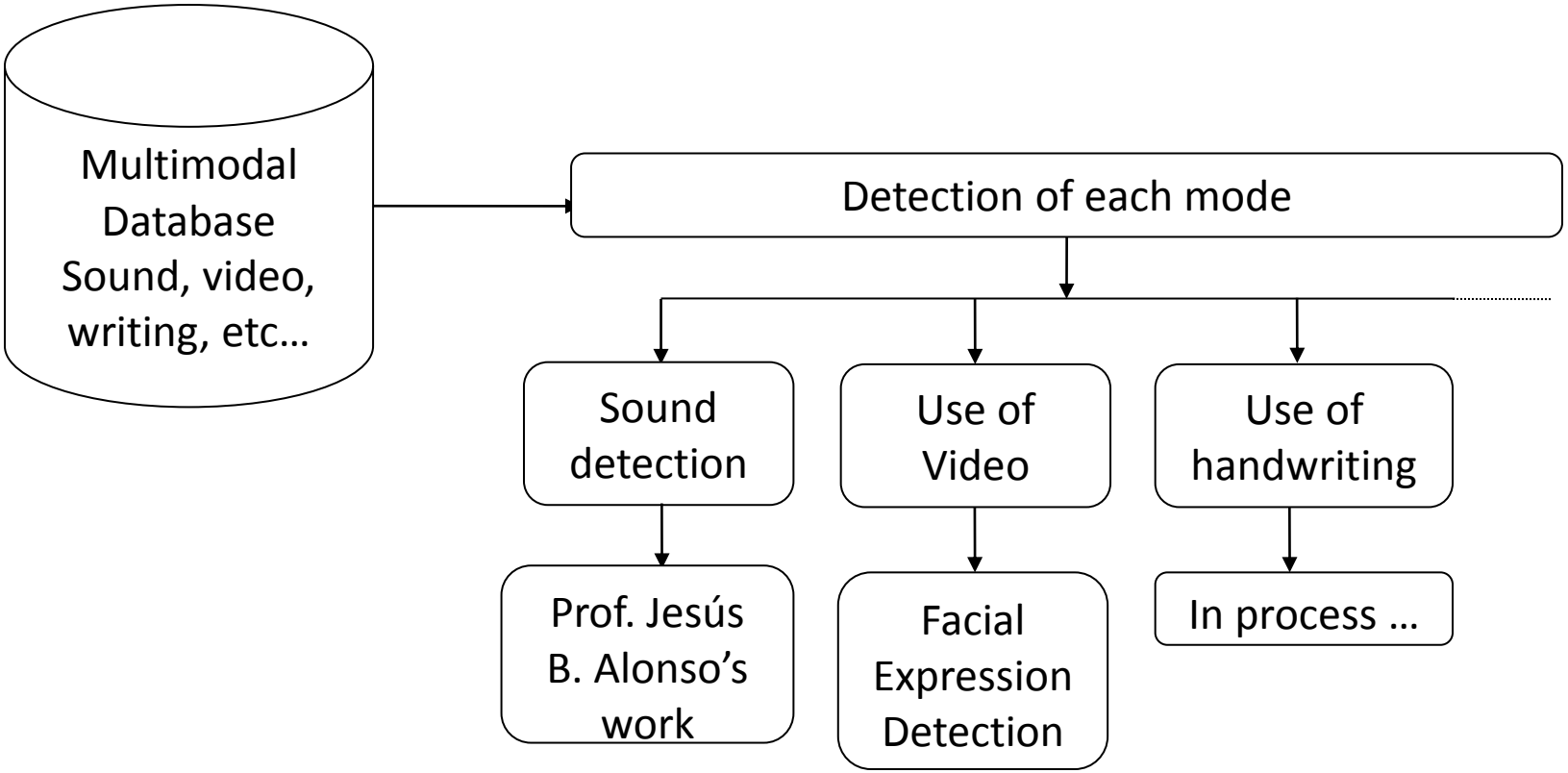
General idea

- The diagram block of our proposal is;



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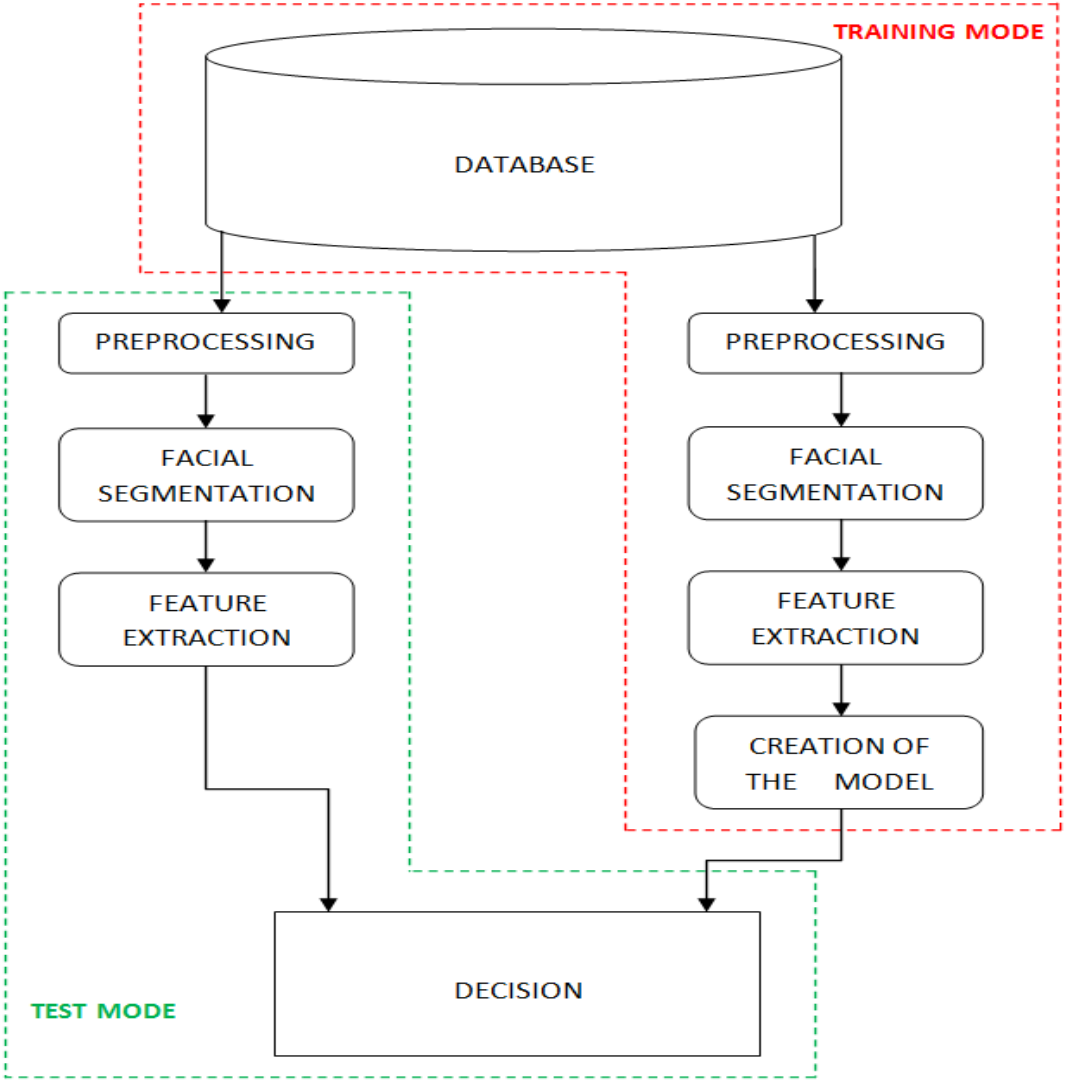
ED: Diagram Block



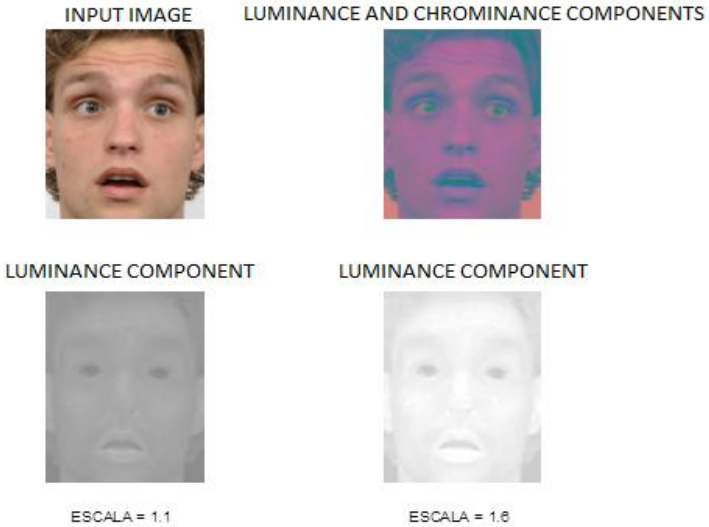
ED: Preprocessing (I)

- The four steps involved in this preprocessing stage include:
  - Extraction of the facial area of the input image
  - Adjusting the brightness of the image
  - Filtering of the images
  - Image binarization

ED: Preprocessing (II)

- An algorithm based on the face detector from Viola and Jones' method

- Adjusting the brightness of the image



ED: Preprocessing (III)

- Filtering of the images

$$\text{MFPA} = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

- Image binarization: Otsu's Method

ED: Facial Segmentation (I)

- It is segmented into seven parts to discern on the information given per each one in our process of emotion detection: forehead, both eyes together, right eye, left eye, right cheek, left cheek and mouth.
  - TP: all segments of the facial image
  - DOLOBO: indicates that both eyes together, right eye, left eye and mouth are used.
  - DOBO: indicates that both eyes together and mouth are used.
  - LOBO: indicates that right eye, left eye and mouth are used.
  - FR: indicates that forehead is used.
  - DO: indicates that both eyes are used together.
  - LO: indicates that right eye and left eye are used.

ED: Facial Segmentation (II)

SEGMENTATION OF THE FOREHEAD

SEGMENTATION OF BOTH EYES TOGETHER

SEGMENTATION OF THE RIGHT EYE

SEGMENTATION OF THE LEFT EYE

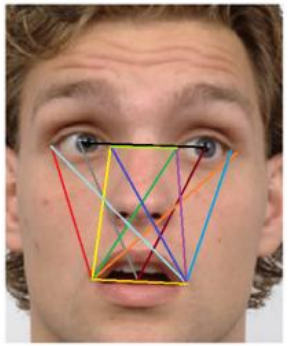
SEGMENTATION OF THE RIGHT CHEEK

SEGMENTATION OF THE LEFT CHEEK

SEGMENTATION OF THE MOUTH

ED: Feature Extraction

- Facial feature extraction in the spatial domain: Euclidean Distances



- Facial feature extraction in transformed domains
  - For this work, the used transformed domains are;
    - 2 Dimensional Discrete Cosine Transform (2D-DCT)
    - 2 Dimensional Discrete Wavelet Transform (2D-DWT).

ED: Classification System

- Support Vector Machine
  - Supervised Approach
  - Use of Linear and Radial Basis Function kernels
  - One vs. All Strategy
- Fusion results
  - This fusion is at the decision level from the output of the SVM decision. Its mission is to correct certain errors, since they are uncorrelated.

ED: Experimental Settings (I)

- Database
  - We used a public database, The Radboud Faces Database (RAFD)
  - Express 8 emotional expressions: anger, disgust, fear, happiness, sadness, surprise, neutral and contempt. Emotions expressed according to FACS (Facial Actions Coding System).
  - The RAFD database is a set of 8040 images of 67 models (20 adult Caucasian male, 19 female Caucasian adults, 4 Caucasian children, 6 girls Caucasian, 18 Moroccan adult male) with 23-24 pictures per model for each position on the camera.

ED: Experimental Settings (II)

- Database

ED: Experimental Settings (III)

- Experiments:
  - In the experiments used SVM with RBF kernel and linear following 50% hold-out validation method, repeating the experiments three times, varying percentages of training and test samples.
  - Therefore, the experiment is divided in three stages:
    - Experiment 1: Feature extraction in the spatial domain: distance measurements are concatenated.
    - Experiment 2: Feature extraction in transformed domains: 2D-DCT and 2D-DWT with Haar family and Bior4.4 family.
    - Experiment 3: Fusion: the best results from the previous experiments.

ED: Experimental Settings (IV)

- Results: Experiment 1
  - The best result obtained using the spatial domain was of 32.58% ± 1.00 with a 50% of training samples and using linear SVM.
  - This approach doesn't give discriminative information

Spatial Domain Results	**SVM**	
	Linear	*RBF*
50% training	32.58% ± 1.00	25.41% ± 0.41
40% training	32.11% ± 0.02	22.77% ± 2.13

ED: Experimental Settings (V)

- Results: Experiment 2
  - All tests are done with 50% of training samples
  - For 2D-DCT, it was 96.16% ± 0.69 with RBF SVM, using TP and 86.41% ± 1.34 with Linear SVM using DOLOBO.
  - For the case of Haar 2D-DWT, the best result obtained was 86.41% ± 1.34 for RBF SVM using TP, and 92.90% ± 0.33 for Linear SVM using TP.
  - For Bior4.4 2D-DWT, 96.33% ± 1.34, using RBF SVM for TP, and 92.95% ± 1.97 for linear SVM using TP.

ED: Experimental Settings (VI)

- Results: Experiment 2
  - The feature extraction of facial features in transformed domains is more effective to detect expressions.
  - The most effective one is Bior4.4 2D-DWT

Transformed Domain Results	**2D-DCT**	
	Linear SVM	***RBF SVM***
50% training (type of segment)	86.41% ± 1.34 (DOLOBO)	96.16% ± 0.69 (TP)
40% training (type of segment)	87.77% ± 0.22 (TP)	90.52% ± 0.09 (TP)

ED: Experimental Settings (VII)

- Results: Experiment 2

Transformed Domain Results	Haar 2D-DWT	
	Linear SVM	***RBF SVM***
50% training (type of segment)	92.90% ± 0.33 (TP)	95.37% ± 1.82 (TP)
40% training (type of segment)	91.18%±0.06 (TP)	94.70% ± 0.62 (DOBO)
Transformed Domain Results	**Bior4.42D-DWT**	
	Linear SVM	***RBF SVM***
50% training (type of segment)	92.95% ± 1.97 (TP)	96.33% ± 1.34 (TP)
40% training (type of segment)	92.46% ± 2.73 (TP)	96.59% ± 0.32 (LOBO)

ED: Experimental Settings (VIII)

- Results: Experiment 3
  - The best result for each percentage linear SVM is chosen for fusion, the result obtained for 50% of samples test was 96.62% success rate with a time of 28.86 milliseconds.
  - For 60% of test samples, the result obtained was 95.72% success rate with a time of 23.80 milliseconds.
  - This decision fusion shows that errors are very correlated, because the improvement is low.

ED: Discussions (I)

- Once realized the study, it has shown that the segmentation of the face, its parametrization with transform domains and the use of SVM classifier gives a much higher percentage of recognition in simulations with transformed domains in the segments of the eye (in whole or separately) and the mouth are present together, reaching accurate of 96.59% using RBF SVM and 2D-DWT bior4.4.

ED: Discussions (II)

- In contrast, the minor influential zones on the detection of emotion are the cheeks and forehead, due to the limited amount of information being given. Especially, the forehead, the results were not higher to 33.33%, using in this case, the Haar wavelet family.

- The importance of the information provided by eyes and mouth is also checked empirically, because when a person shows emotions, like surprise, the parts of the face that more quickly and clearly serve as indicative are the eyes and mouth.

ED: Discussions (III)

- By showing the eyes and mouth wide open, the emotion can be detected without any doubts.
- Which does not occur with the cheeks and forehead if considered separately, because the movements of the muscles associated with these areas is inconclusive in this study.
- BIOSIGNALS 2013 - Third International Special Session on Multivariable Processing for Biometric Systems - MPBS 2013

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Use of handwritten information (I)

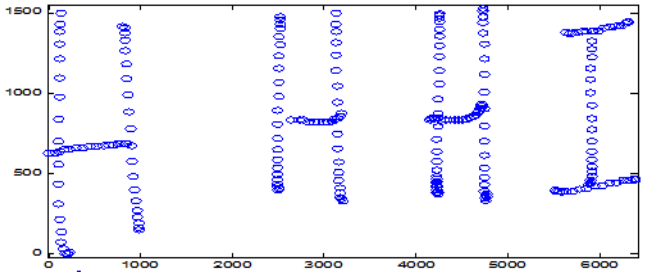
- Another important information source is the use of handwritten information.
- We have a large background working in signature verification and writer identification, under off-line and on-line conditions.
- The idea is the use of online information, because it gives us more details and calculate different kind of parameters.

Francisco Vargas, Carlos M. Travieso, Jesús B. Alonso, Miguel A. Ferrer, Off-line Signature Verification Based on Grey Level Information using Texture Features, **Pattern Recognition**, 44 (2), pp. 375-385, 2011

Omar Santana, Carlos M. Travieso, Jesús B. Alonso, Miguel A. Ferrer, Writer Identification Based on Graphology Techniques, **IEEE Aerospace and Electronic Systems Magazine**, 25 (6), pp. 35-42, 2010

Use of handwritten information (II)

- We are beginning a collaboration with Prof. Karmele Lopez-de-Ipiña, and the idea is to use the following parameters as measure of the Neurodegenerative diseases;
  - Number of strokes
  - Variability /Tremor
  - Time
  - Pressure
  - Derivation
  - Temporal evolution
  - etc ....



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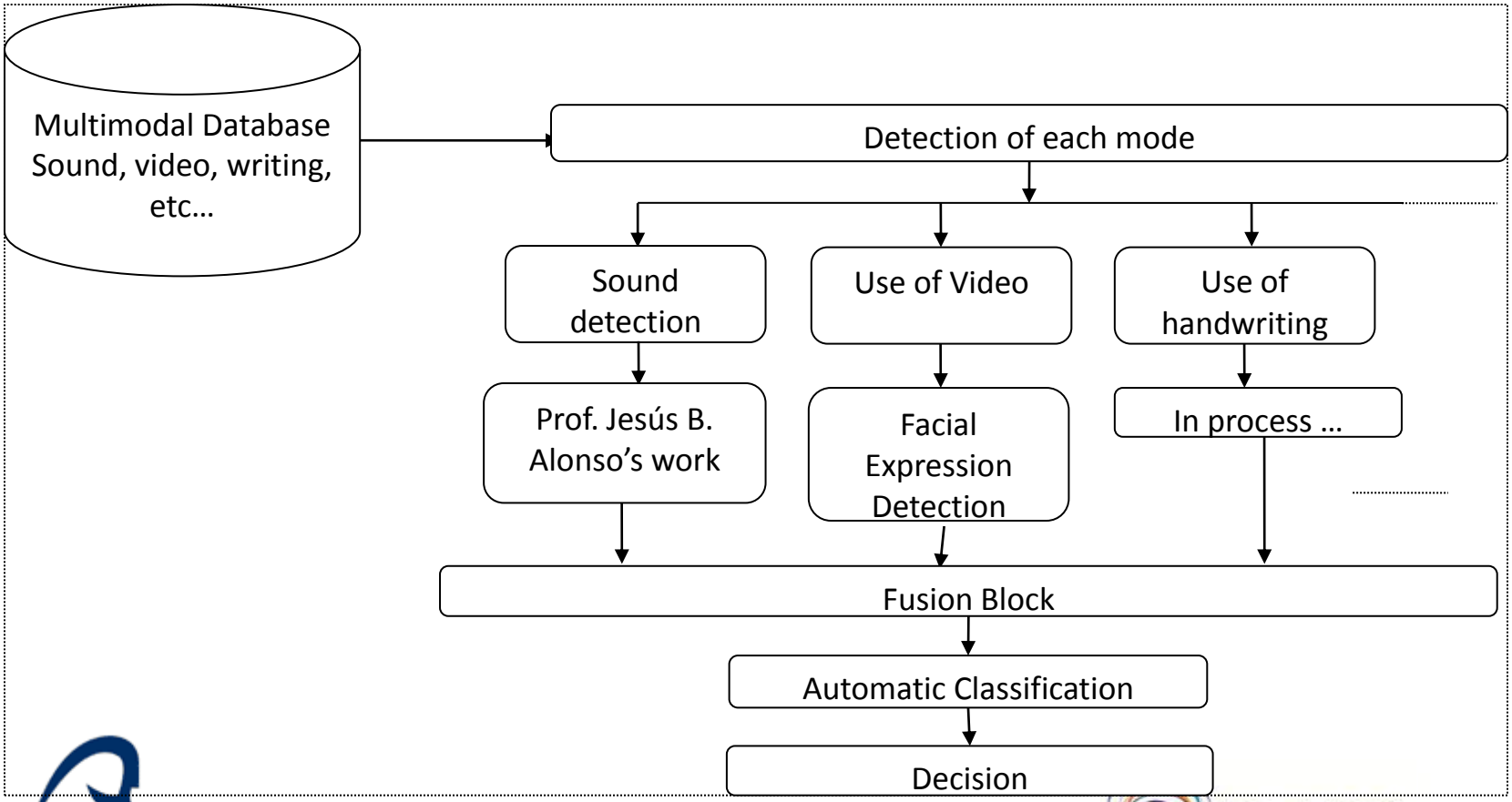
Fusion Approach from different sources

- The idea is to use different kinds of sources in order to get a robust emotion detection.



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Conclusions

- We have started to develop a multimodal expression detection, where the facial expression and voice emotion detection blocks have been done, with good results.
- We are working on the recording protocol, in order to have a multimodal approach.
- In a close future, we will begin to work with writing and the whole fusion block.

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Acknowledgement

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