ESTIMATION OF FACIAL EXPRESSION INTENSITY BASED ON THE BELIEF THEORY

Khadoudja Ghanem[1], Alice Caplier[2] and Sébastien Stillittano[2]
[1]*Laboratory Lire, Mentouri University , Rue Ain El Bey, Constantine, Algeria*
[2]*GIPSA-lab/DIS 46 avenue Félix Viallet, F-38031 Grenoble, France*

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Abstract: This article presents a new method to estimate the intensity of a human facial expression. Supposing an expression occurring on a face has been recognized among the six universal emotions (joy, disgust, surprise, sadness, anger, fear), the estimation of the expression's intensity is based on the determination of the degree of geometrical deformations of some facial features and on the analysis of several distances computed on skeletons of expressions. These skeletons are the result of a contour segmentation of facial permanent features (eyes, brows, mouth). The proposed method uses the belief theory for data fusion. The intensity of the recognized expression is scored on a three-point ordinal scale: "low intensity", "medium intensity" or " high intensity". Experiments on a great number of images validate our method and give good estimation for facial expression intensity. We have implemented and tested the method on the following three expressions: joy, surprise and disgust.

1 INTRODUCTION

Technology occupies a prominent place in our society, but the users have not any more time to adapt themselves to the increasingly complexity of machines. This is why the machine has to adapt itself to the user by proposing him/her a convivial and ergonomic interface.

In order to make the human/computer communication easier, it is necessary to equip the machine with an emotional system. According to (Bui *et al.,* 2002), an emotional system must be quantitative and able to produce emotions with various intensities decreasing along the time; Edwards (Edwards, 1998) stresses the importance of quantitative models of emotions and is astonished that few researchers are interested in computation of emotions intensities. In the scope of an effective model of the dialogue, it is essential to associate intensity to the emotion, because it will not influence the dialogue in the same way according to its degree. Thus a slightly irritated person will not behave in a violent way as a furious person against his/her interlocutor.

Like in psychology, psychoanalysis, biology (Darwin), philosophy (Descartes), medicine, tele-formation, the simulation of people in virtual reality, the control of vigilance for a driver, the interactive plays or in videoconferences, the recognition of facial expressions with their intensities is involved in the making decision process of the behavior of the interlocutor, that it is a machine or a human being.

It will be a great challenge and be of practical significance to estimate expression intensities. Researchers in facial expressions field are influenced by Ekman, Friesen and Izard so that they work generally on the six universal expressions (joy, disgust, surprise, sadness, anger, fear). But with the study of the intensity of each expression, we can make leave sub expressions classes. For example, for anger we can deduct: rage, anger or boredom and for fear: anxiety, fear or terror.

Several computer vision researchers proposed methods to represent intensity variations (I. Essa and A. Pentland, 1997) represented intensity variation in joy using optical flow. (Kimura and Yachida, 1997) and (Lien. *et al.,* 1998) quantified intensity variation in emotion-specified expression and in action units, respectively. These authors did not, however, attempt the more challenging step of discriminating intensity variation within types of facial actions. Instead, they used intensity measures for the limited purpose of discriminating between different types of facial actions. (Bartlett,

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1999) tested their algorithms on facial expressions that systematically vary in intensity as measured by manual FACS coding. Although they failed to report results separately for each level of intensity variation, their overall findings suggest some success. (Tian *et al.*, 2000) may be the only group to compare manual and automatic coding of intensity variations. Using Gabor features and an artificial neural network, they discriminate intensity variation in eye closure as reliably as human coders do.

In this article we present a new method to estimate, from still images, the intensity of a human facial expression recognized among the six universal emotions (smile, disgust, surprise, sadness, anger and fear).

This method is mainly based on the determination of the degree of geometrical deformations of some facial features and on the analysis of certain distances computed on skeletons of expressions. A skeleton is the result of a contour segmentation of face permanent features such as eyes, brows and mouth (See Fig. 1). We compute distances which are showed on Fig 1, then we define a model for each considered distance with three score levels of intensity « Low, Medium and High ». Each distance relevant to each expression is classified into one of the three levels or between two levels, with a piece of evidence associated to each level. While all the distances are treated, a process of data fusion is carried out to give a final intensity classification and consequently deduce new sub expressions.

2 RELATED WORK

Our method is applied to still images on which the facial expression is supposed to be known. We compute distances which are showed on Fig 1 and Fig.2 to estimate expression intensity.

These distances are normalized with respect to the distance between the centers of both irises. This makes the analysis independent on the variability of face dimensions and on the position of the face with respect to the camera.

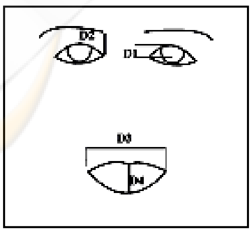


Figure 1: Facial skeleton and characteristic distances.

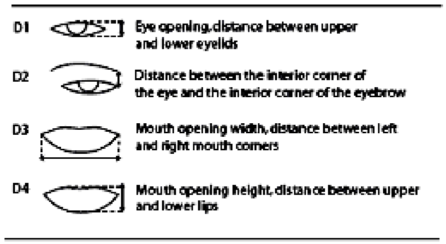


Figure 2: Characteristic distances computed on facial skeleton images.

2.1 Relevant Distances for the Estimation of the Intensity of an Expression

Ekman proposed a ***Facial Action Coding System;*** his system contains 44 Action Units (AUs) (P. Ekman, 2002). The intensity of an AU can be scored on a five-point ordinal scale (A, B, C, D, E) as shown on Fig. 3. FACS uses conventions or rules to set thresholds for scoring the intensities of an AU.

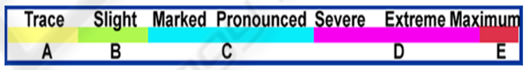


Figure 3: The different levels in scoring intensities of an action unit (P.Ekman, 2002).

The A-B-C-D-E scoring scale is not an equal interval scale; the C and D levels cover a larger range of appearance changes than the other levels, and most of the AU variations fall in these levels. The A, B, and E levels are defined as very narrow ranges. The A and B levels are often confused, the separation between D and E is difficult to determine and even the *trace* of A and the *maximum* of E refer to a limited range of appearance changes.

Combination of two or more AUs changes the AU intensity. For all these reasons, we have reduced the number of levels to three: “Low level” replaces A and B; « Medium level » replaces C and « high level » replaces D and E. And we suppose that the three levels are equal.

Whether we score the intensity or not, and which AUs intensity is scored, will depend on the purposes of the investigation. In our case we need to study the mouth’s opening (horizontally and vertically), eyes’ opening and closing and the raising of eyebrows.

In the mouth’s region, the AUs 12, 13, 14 correspond to the horizontal opening; in terms of distance, D3 replaces these three AUs. The AUs 25, 26, 27 correspond to the vertical opening; in terms of distance, D4 replaces these three AUs.

In the eye's region, the AUs 1, 2, 4 represent the intensity's variation from low to raised brows. In terms of distance, D2 replaces these three AUs. The AUs 41, 42, 43 or 45 represent the intensity's variation from slightly drooped to closed eyes. In terms of distance, D1 replaces these three AUs.

2.2 Belief Theory

Initially introduced by (A. Dempster, 1967) and (Shafer, 1976), and enriched by (P. Smets, 1994), the belief theory considers a frame of discernment $\Omega = \{E1, ..., EN\}$ of N exhaustive and exclusive hypotheses characterizing some situations. This means that the solution of the considered problem is unique and that it is obligatorily one of the hypotheses of Ω. This approach takes into account the uncertainty of the input information and allows an explicit modeling of the doubt between several hypotheses, for example the different intensities of expressions. It requires the definition of a Basic Belief Assignment (BBA) that assigns an elementary piece of evidence $m(A)$ to every proposition A of the power set 2^Ω. The function m is defined as:

$$m : 2^\Omega \rightarrow [0, 1]$$
$$A \rightarrow m(A), \ \sum m(A) = 1, A \subseteq \Omega \quad (1)$$

In our application, the assumption Ei_min corresponds to the minimum or low expression intensity of expression *i*; Ei_moy corresponds to the medium intensity and Ei_max corresponds to the maximum or high intensity. 2^Ω corresponds to single expression intensities or to combinations of expression intensities, that is 2^Ω = {Ei_min, Ei_moy, Ei_max ,(Ei_min∪Ei_moy), (Ei_moy∪Ei_max),…}, and A is one of its elements. In that definition, any kind of expression Ei can be considered.

2.3 Definition of Symbolic States

We associate a state variable Vi ($1 \leq i \leq 4$) to each characteristic distance *Di* in order to convert the numerical value of the distance to a symbolic state. The analysis of each variable shows that *Vi* can take three possible states, $\Omega' = \{min, moy, max\}$; $2^{\Omega'} = \{min, moy, max, minUmoy, moyUmax\}$ where *minUmoy* states the doubt between *min* and *moy*, *moyUmax* states the doubt between *moy* and *max*. We assume that impossible symbols (for example *minUmax*) are removed from $2^{\Omega'}$.

2.4 Modeling Process

The modeling process aims at computing the state of every distance *Di* and at associating a piece of evidence. To carry out this conversion, we define a model for each distance using the states of $2^{\Omega'}$ (Figure 4).

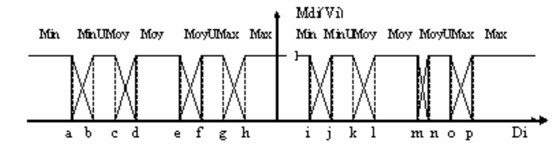


Figure 4: Proposed model.

One model is defined for each characteristic distance independently of the facial expression. If the calculated distance increase , we consider the right half part of the model from *i* to *p* thresholds, and if the calculated distance decrease, we consider the left half part of the model with from *a* to *h* thresholds like on figures 5,6 and 7. For each value of *Di*, the sum of the pieces of evidence of the states of *Di* is equal to 1.

$$m_{Di} : 2^{\Omega'} \rightarrow [0, 1] \quad (2)$$
$$V_i \rightarrow m_{Di}(V_i)$$

The piece of evidence $m_{Di}(V_i)$ is obtained by the function depicted in Figure 4.

2.5 Definition of Thresholds

Thresholds {a,b,…. P} of each model state are defined by statistical analysis on (Hammal_Caplier) Database. The database contains 21 subjects, it has been divided into a learning set called HCE_L and a test set called *HCE* . The learning set is then divided into expressive frames noted HCE_{Le} and neutral frames HCE_{Ln}.

The minimum threshold *a* is averaged out over the minimum values of the characteristic distances from the HCE_{Le} database. Similarly, the maximal threshold *p* is obtained from the maximum values. The middle thresholds *h* and *i* are defined respectively as the mean of minimum and maximum of the characteristic distances from the HCE_{Ln}. The threshold *b* is the median of the characteristic distances values for facial images assigned to the higher state *min, g* is the median of the characteristic distances values for facial images assigned to the lower state *S.* The intermediate threshold *d* is computed as the mean of the difference between the limit thresholds *a* and *h* divided by three (according to the supposition in section 2.1) augmented by the value of the threshold *a*. Likewise the threshold *e* is computed as the mean of the difference between the limit thresholds *a* and *h* divided by three reduced by the value of the threshold *h*. The thresholds *c* and *f* are computed as the mean of thresholds *b* and *d* respectively *e* and *g*. The thresholds from the positive part of the proposed model are computed similarly.

2.6 Definition of Expression Intensities

Due to a lack of data, only three expressions (joy, disgust and surprise) were used to evaluate expression intensities.

2.6.1 *Joy* Expression E_1

The most important changes appearing on the face when smiling are the followings: the corners of the mouth are going back toward the tears (V_3 goes from *min* to *max*) and the eyes become slightly closed (V_1 goes from *max* to *min* see tab.1) so the most important distances considered in the estimation of intensity of *joy* expression are D_1 and D_3 (see Fig.5):

Table 1: Mapping table between characteristic distances and state variables for *joy* expression E1.

	V1	V3
E1_min	Max	Min
E1_moy	MoyUMax	MoyUMin
E1_max	Min	Max

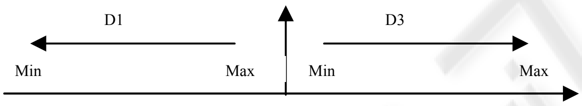


Figure 5: Evolution of distances in case of *joy* expression E_1.

2.6.2 *Surprise* Expression E_2

The most important changes appearing on the face with a *surprise* expression are: the mouth is opening vertically (V_4 goes from *min* to *max*), the eyes are opening (V_1 goes from *min* to *max*) and eyebrows are raised (V_2 goes from *min* to *max* see tab 2). So the most important distances considered in the estimation of intensity of a *surprise* expression are D_1, D_2 and D_4 (see Fig 6).

Table 2: Mapping table between characteristic distances and state variable for *surprise* expression E_2.

	V1	V2	V4
E2min	Min	Min	Min
E2moy	Moy	MoyUMin	MoyUMin
E2max	Max	Max	Max

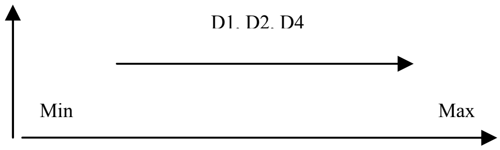


Figure 6: Evolution of distances in case of *surprise* expression.

2.6.3 *Disgust* Expression E_3

The most important changes appearing on the face with a *disgust* expression are: the mouth is opening (V_4 go from *min* to *max*) and the eyes become slightly closed (V_1 go from *max* to *min* see tab.3). So the most important distances considered in the estimation of intensity of *disgust* expression are D_1 and D_4 (see Fig. 7).

Table 3: Mapping table between characteristic distances and state variables for *disgust* expression E_3.

	V1	V4
E3min	Max	Min
E3moy	MoyUMax	Moy
E3max	MinUMoy	Max

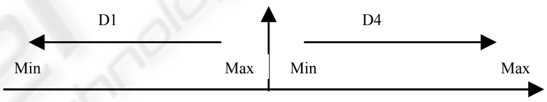


Figure 7: Evolution of distances in case of *disgust* expression.

2.7 Logical Rules between Symbolic States and Facial Expressions

As soon as the characteristic distances states are assigned to each distance, we have to refine the process by formulating the joint Basic Belief Assignment in terms of facial expressions. To do so, we use tables of logical rules. As an example, Table 4 gives the logical rules for D_1 and D_3 for the *joy* expression.

Table 4: Logical rules for D_1 and D_3 for *joy* expression.

Vi	State Value	E1_min	E1_moy	E1_max
V1	Min	0	0	1
	Moy	0	1	0
	Max	1U0	1U0	0
V3	min	1U0	1U0	0
	Moy	0	1	0
	max	0	0	1

If a state is reached by an expression, we have ”1”, and “0” otherwise. This table can be interpreted as:

if V_1 = m*ax* then the reached expression corresponds to *E1_minUE1_moy,* it means that:

$m_{D1}(max)=m_{D1}(E1\_minUE1\_moy)$
$m_{D1}(moy)=m_{D1}(E1\_moy)$
$m_{D1}(min)=m_{D1}(E1\_max)$
$m_{D3}(max)=m_{D3}(E1\_max)$
$m_{D3}(moy)=m_{D3}(E1\_moy)$
$m_{D3}(min)=m_{D3}(E1\_minUE1\_moy)$

2.8 Data Fusion and Global Belief Assignment Computation

In order to make the decision about the intensity of facial expression, the available information m_{Di} is combined to be integrated with the (Dempster, 1967) combination law (conjunctive combination). For example we consider two characteristic distances *Di* and *Dj* to which we associate two Basic Belief Assignments m_{Di} and m_{Dj} defined on the same frame of discernment 2^{Ω}. Then the joint Basic Belief Assignment m_{Dij} is given using the conjunctive combination (orthogonal sum) as:

$$m_{Dij}(A) = (m_{Di} \oplus m_{Dj})(A) = \sum_{B \cap C = A} m_{Di}(B) m_{Dj}(C) \quad (3)$$

Where *A*, *B* and *C* denote propositions and $B \cap C$ denotes the conjunction (intersection) between the propositions *B* and *C*.
To be more explicit, we consider these Basic Belief Assignments (see tab.5):

$m_{D1}(minUmoy)=m_{D1}(E1\_maxUE1\_moy)$
$m_{D1}(moy)=m_{D1}(E1\_moy)$
$m_{D3}(moy)=m_{D3}(E1\_moy)$

Table 5: Example of combinations of two distances.

D1/D3	E1_minUE1_moy	E1_moy
E1_moy	E1_moy	E1_moy

mD13(E1_moy)=
mD1(E1_minUE1_moy).mD3(E1_moy) + mD1(E1_moy).
mD3(E1_moy)

2.9 Post-processing in Case of Conflict

Some times, the empty set appears in the combination table of distances. It corresponds to situations where the values of characteristic distances leading to symbolic states configuration do not correspond to any of the definitions of any expression (see tab.6-7). This has to be related to the fact that Ω is not really exhaustive .In the reality, every body expresses his emotions differently, some times he opens his eyes, raises his eyebrows but does not open his mouth in the case of surprise (see Fig.8).

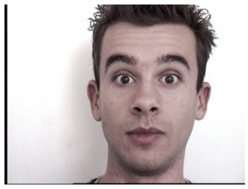


Figure 8: Example of *surprise* with conflict

$m_{D1}(moy)=1=m_{D1}(E2\_moy)$
$m_{D2}(max)=1= m_{D2}(E2\_max)$
$m_{D4}(moy)=1=m_{D4}(E2\_moy)$

Tables 6-7: Examples of combination of three distances.

D1/D4	E2_moy
E2_moy	E2_moy

$m_{D14}(E2\_moy)=m_{D1}(E2\_moy).m_{D4}(E2\_moy)$

D14/D2	E2_moy
E2_max	Ø

Error

In these cases, we propose a solution as a post processing. According to FACS Investigator's Guide, the number of activated AUs is used to estimate the intensity of an expression. If only 2 AUs from 4 are activated when an expression is expressed, we can say that the intensity is not *max*. In the same way, when we have one distance which is not at its limit (*max* or *min*), the expression is not at its limit too (*max* or *min*) so it is a medium expression intensity.

2.10 Decision

The decision is the last step of the process. It consists in making a choice between three intensity assumptions and their possible combinations. Making a choice means taking a risk, except if the result of the combination is perfectly reliable: *m(Ei)= 1*. Here, the selected proposal is the one with the maximum value of the piece of evidence.

3 EXPERIMENTS AND RESULTS

3.1 Results on Hammal_Caplier Database

The best way to experiment our algorithm on different intensities is to test it on video recordings of different subjects expressing different expressions. The face changes from expressionless to an expression with maximal intensity, and then changed back to an expressionless face starting and ending by a neutral state, passing by different intensities (see Fig.9). The (Hammal_Caplier) database contains 21 subjects, 3 expressions *Joy, Surprise and Disgust* and each video contains 100 frames .

For the expertise step of the Belief theory, we have considered 10 subjects for each expression. 10 cases of low intensity which correspond to the first frame of the video recording where a human expert can distinguish the first changes on the face; 10 cases with high intensity which correspond to the apex of each expression; 10 cases with medium intensity taken from the video recordings corresponding to the face changes from the expressionless to the expression with maximal intensity and 10 other cases of medium intensity taken from the video recordings corresponding to changing back to an expressionless face, images on figures 16,17 and 18 shows different intensities min, moy and max of joy surprise and disgust expressions respectively.

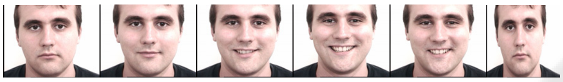


Figure 9: Example of 6 images from a Video recording of a *Joy* expression.

As entries of our algorithm, we have the recognized expression, then different distances are computed, and the Belief theory is applied to give the results of table 8:

Table 8: Classification rates in percent for 3 intensities of each expression from the 3 expressions *Joy*, *Surprise* and *Disgust* on the *HCE database.*

Exp.	recognized	Doubt min/moy	Doubt moy/max	Error
E1min	70%	30%	0%	0%
E1moy	95%	0%	5%	0%
E1max	100%	0%	0%	0%
E2min	52,89%	47,11%	0%	0%
E2moy	81,25%	0%	0%	18,75%
E2max	66,66%	0%	0%	33,33
E3min	32,5%	42,5%	0%	25%
E3moy	53,85%	7,69%	0%	38,5%
E3max	62,5%	0%	12,5%	25%

In this table, lines correspond to different intensities of each of the three expressions (*Joy* E1; *Surprise* E2; *Disgust* E3), and columns correspond to rates of different cases. The first column corresponds to rates of recognized intensity of the appropriate expression, the second column corresponds to rates of images from the database for which there is a doubt between minimum and medium intensity of the expression, the third column corresponds to rates of images from the database for which there is a doubt between the medium and maximum intensity of the expression and the last column corresponds to the cases where an error occurs.

We observe that the best results are obtained in case of *joy* expression. We observe also that good rates are obtained when we have medium or maximum intensity of an expression. On the contrary rates obtained with minimum intensity are lower, this can be explained by the fact that the HCE database has been created to identify expressions (*joy* , *surprise* and *disgust*) and not to estimate intensities so most of the subjects can not express their emotions with minimum intensity for all features and they do not spend enough time in expressing minimum intensity of the expression. They pass directly to the apex of the expression. For example, in case of *surprise* we can observe quick changes to reach the apex expression (see Fig.10):

Figure 10: Example of video recording of *surprise* expression without passing by minimum intensity.

We also observe that although it is about the same expression, there are some errors; this can be explained by the fact that most subjects express emotions by giving the maximum intensity to some features and not enough to another one, for example see Fig.11:

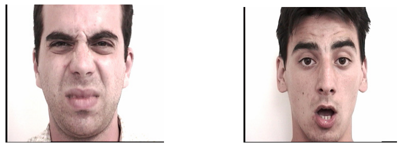
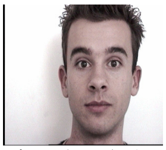


Figure 11: Example of conflict in *disgust* on the left and *surprise* expression on the right respectively.

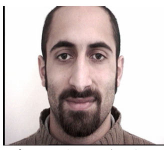
From the left of Figure 11, one can see that the subject with disgust expression has closed his eyes, so the piece of evidence given to the state of the distance D1 correspond to high intensity, on the other hand his mouth is hardly open so the piece of evidence given to the state of distance D4 correspond to medium intensity, the combination of the two distances gives an error. In the same way, from the right of Figure 11, one can see that the subject with surprise expression has opened widely the mouth so the piece of evidence given to the state of distance D4 correspond to high intensity and on the other hand he fairly opened his eyes, and fairly raised his eyebrows so the pieces of evidence given to the states of the distances D1 and D4 correspond to medium intensity, the combination of the three distances gives an error.

Finally, we can observe that when we have minimum intensity of expressions, we can have a rate for the doubt between minimum intensity and medium one but zero doubt between minimum intensity and maximum one (0%). In the case of medium intensity we can get doubt between medium and minimum or between medium and maximum intensity and in the maximum case, we can get doubt between minimum and medium but zero doubt between maximum and minimum (see Fig 12, 13 and 14).


mD124(E2minUE2moy)=1


mD14(E3minUE3moy)=1

Figure 12: Example of doubt between minimum and medium intensity in case of *surprise* expression on the left and *disgust* on the right.


mD13(E1minUE1moy)=1


mD13(E1moyUE1max)=0.976

Figure 13: Example of doubt between minimum and medium intensity in case of *joy* on the left and doubt between medium and maximum intensity in case of same expression on the right.

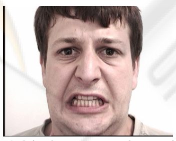

mD14(E3moyUE3max)=1

Figure 14: Example of doubt between medium and maximum in *disgust* expression.

In order to eliminate errors we can add the post processing. To do so, we consider that if we have one of the characteristic distances taken in the count to estimate the intensity of an expression which is not equal to its limit (*max* or *min*) we can say that we have a medium intensity.

We can also use this method to estimate expression intensity but obtained results are less correct than ones obtained using the belief theory. It could be preferable to keep the doubt between two intensities instead of taking the risk of choosing the wrong one. The TBM are actually well adapted for such a scenario. Figure 15 shows an example of intensity estimation with and without the belief theory.

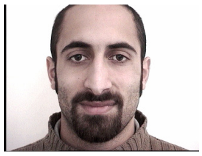


Figure 15: Doubt between min and moy intensity.

Results with the belief theory :

mD1(max)=1=mD1(E1minUE1moy)
mD3(minUmoy)=1= mD3(E1minUE1moy)
mD13(E1minUE1moy)=1

Results with the other method :

V1=max ; V3=minUmoy
⇨ E1moy

An expert says that it is righter if we say that it can be a minimum and it can be a medium intensity , than when we say that it is a medium intensity so the belief theory is more exact than the other method.

With the proposed post processing step, the recognition rate changes and the rates of errors are added to recognized ones , for the doubt state min-moy or moy-max, the system is sure that the current intensity of the expression is one of these two ones and that it is not the third one. It is thus possible to consider it as a good classification and we can associate it to the corresponding intensity. This allows us to add their respecting rates leading to the rates of recognized ones and then we get at the end of the process a recognized intensity of every state of any expression (*Joy*, *Surprise* and *Disgust*) (see Tab. 9).

Table 9: Classification rates in percent for 3 intensities of each expression from the 3 expressions *Joy*, *Surprise* and *Disgust* on the HCE database after the post processing.

Exp.	recognized	Doubt min/moy	Doubt moy/ max	Error
E1min	70%	30%	0%	0%
E1moy	95%	0%	5%	0%
E1max	100%	0%	0%	0%
E2min	52,89%	47,11%	0%	0%
E2moy	100%	0%	0%	0%
E2max	100%	0%	0%	0%
E3min	57,5%	42,5%	0%	0%
E3moy	92,11%	7,69%	0%	0%
E3max	87,5%	0%	12,5%	0%

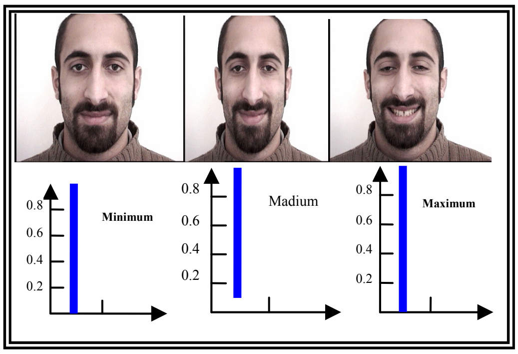


Figure 16: Example of Minimum, medium and maximum Intensities of *Joy* on the first row and the correspondent piece of evidence on the second row.

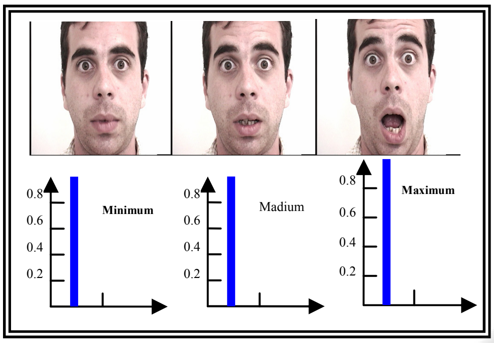


Figure 17: Example of Minimum, medium and maximum Intensities of *surprise* expression on the first row and the correspondent piece of evidence on the second row.

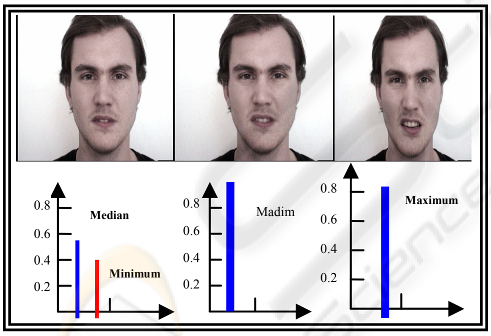


Figure 18: Example of Minimum, medium and maximum Intensities of *disgust* expression on the first row and the correspondent piece of evidence on the second row.

3.2 Results on EEbase Database

In order to evaluate the robustness of the proposed recognition system to different variations, the system is also tested on the (EEbase database). This database contains 43 subjects, 24 males and 19 females, for each subject, we have 16 frames in neutral, joy, disgust, sadness, anger, surprise and fear expressions. For the joy expression we have 3 frames which represent three intensities (low, medium and high), for the disgust expression we have two intensities (medium and high) and for the surprise expression we have only the high intensity. To compute the rates of recognition intensities on this database, we have considered 21 subjects (see Tab.10).

Table 10: Classification rates in percent for 3 intensities of each expression from the 3 expressions *Joy*, *Surprise* and *Disgust* on the "eebase" database.

Exp.	recognized	Doubt min/moy	Doubt moy/max	Error
E1min	50%	50%	0%	0%
E1moy	70%	0%	30%	0%
E1max	100%	0%	0%	0%
E2min	Images not available			
E2moy	Images not available			
E2max	100%	0%	0%	0%
E3min	Images not available			
E3moy	70%	0%	0%	30%
E3max	90%	0%	10%	0%

In this table, we can see that we are about the same observations when testing the first experimental database.

Figure 19: Examples of classification on other images from other databases.

4 CONCLUSIONS

In this paper, we have presented a new method to estimate human facial expression intensities by using the belief theory.

This method takes into account the most important changes which appear on human face when expressing an emotion. By interpreting these changes in terms of distances, results given by our method have proved that the most important factor to estimate expression intensity is the degree of geometrical deformation of facial structures which are interpreted by the proposed distances (D1, D2, D3, D4). Since the Transferable Belief Model has proved its ability to deal with imprecise data, and its interest to model the doubt between expression intensities, it is used for the fusion of the available information to provide more reliable decisions. Our aim is then to validate our algorithm on the three other expressions Fear, Sadness and Anger, and then, confirm these results on natural expressions.

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Hammal_Caplier Database : http://www.lis.inpg.fr/pages_perso/caplier/english/emotionnelle.html.en/emotionnelle_2.html.en.html

EEBase Database : http://www.cs.cmu.edu/afs/cs/project/cil/ftp/html/v-images.html