Recunoasterea expresiilor faciale

Interfatare vizuala om-masina

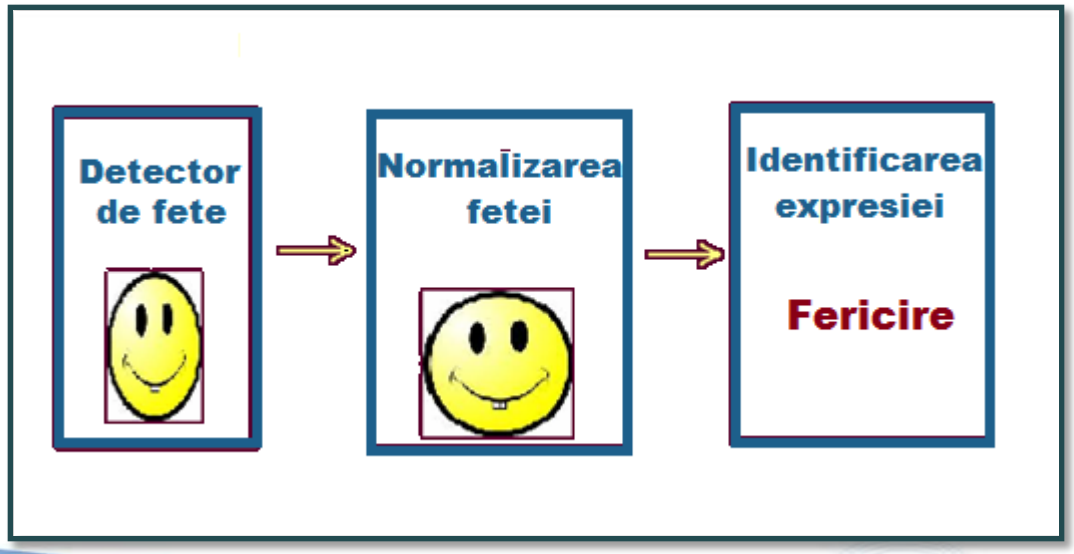
Corneliu Florea

Cuprins

1. Definirea problemei
    1. Aplicatii
2. Suport anatomic/psihologic
    1. Sistemul FACS
    2. Alte masuri
3. Solutii :
    1. Analiza unei secvente de imagini
    2. Analiza portretului

Recunoasterea emotiei

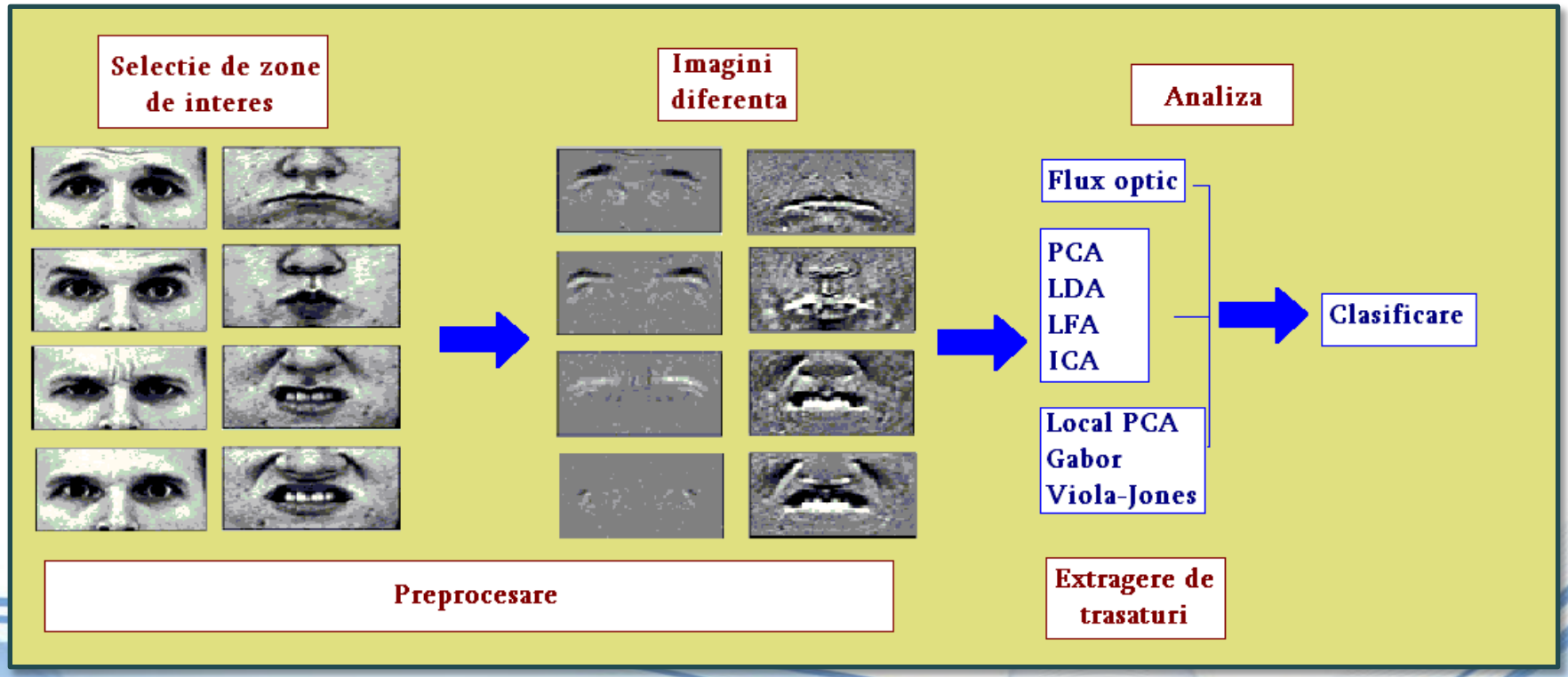
Problema principala: identificarea expresiei fundamentale a unei persoane prin analiza trasaturilor faciale



Probleme secundare:

- Identificarea intensitatii emotiei generatoare
- Detectia veridicitatii (expresia este cauzata de emotie sau simulata)

Schema generala



Aplicatii

Aplicatii ale recunoasterii expresiilor:

- Jocuri – intensitatea si directia de dezvoltare sunt modificate in functie de reactia emotionala
- Monitorizarea comunicatiei - utilizatorul este atentionat in momentul cand vrea sa dea un raspuns sub influenta unei emotii puternice
- Securitate – expresia este utilizata pentru a evidentia daca cineva are ceva de ascuns
- Medicina – studii psihologice:
  - Antrenarea copiilor autisti
  - Estimarea intensitatii durerii
  - Detectia depresiei

Si inca o aplicatie







Expresii Fundamentale

- Tristete
- Furie
- Fericire
- Teama
- Dezgust
- Surpriza
- Neutru

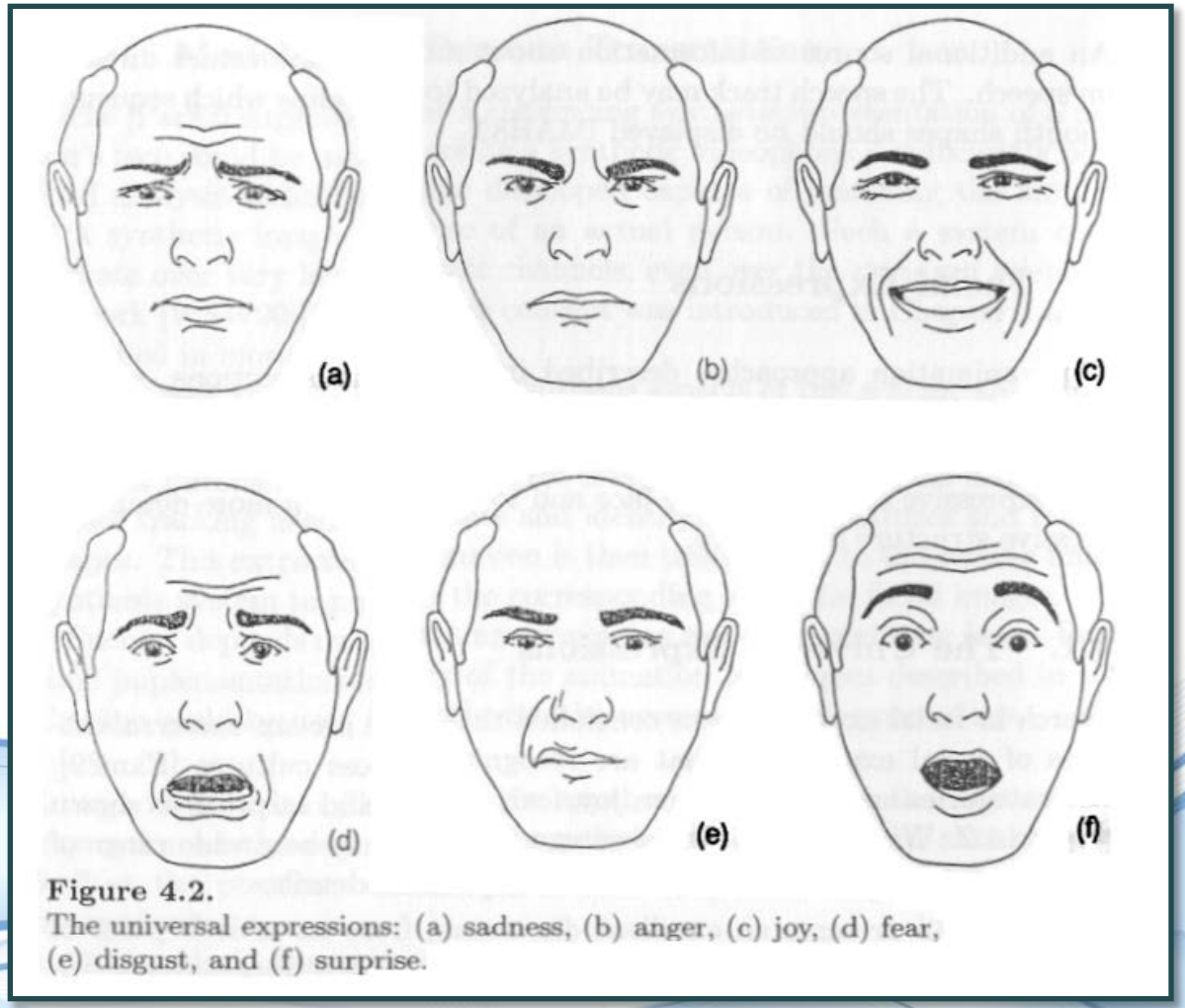


Figure 4.2.
The universal expressions: (a) sadness, (b) anger, (c) joy, (d) fear, (e) disgust, and (f) surprise.

Confuzie intre expresiile de baza

Pentru **observatori** umani expresiile de baza nu sunt intotdeauna separabile

$\tau(\varepsilon_1, \varepsilon_2)$	Furie	Dezgust	Frica	Fericire	Tristete	Supriza
Furie	100.0%	42.4%	23.8%	7.3%	43.2%	28.9%
Dezgust	42.4%	100.0%	32.6%	6.2%	19.3%	24.6%
Frica	23.8%	32.6%	100.0%	11.0%	15.8%	43.8%
Fericire	7.3%	6.2%	11.0%	100.0%	6.7%	14.5%
Tristete	43.2%	19.3%	15.8%	6.7%	100.0%	28.9%
Supriza	28.9%	24.6%	43.8%	14.5%	28.9%	100.0%

$$\tau(\varepsilon_1, \varepsilon_2) = \frac{H(\varepsilon_1 AND \varepsilon_2)}{H(\varepsilon_1 OR \varepsilon_2)}$$

Expresii derivate

1. Grade de intensitate pentru expresiile de baza

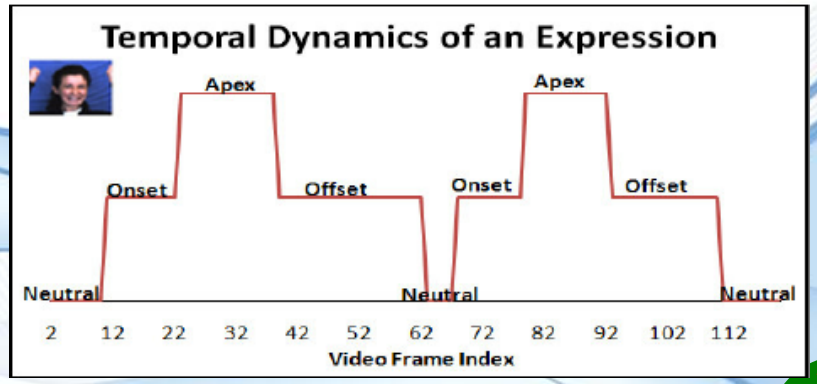
Tristete	Furie	Fericire	Teama	Dezgust	Surpriza
Dezamăgire Tristeţe Deprimare	Frustrare Enervare Furie Furie nebuna	Placere Fericire Extaz	Spaima Frica Sperietura	Dezgust Sila	Surpriză Uimire Uluire

2. Expresii obtinute prin amestecul expresiilor de baza
   ex: **Surpriza + Fericire**

[Zucker]

Trasaturi relevante expresiilor

- Analiza faciala bazata pe trasaturi trebuie sa tina cont de :
  - **Localizare** – identificarea trasaturilor de interes
  - **Intensitate** –se determina:
    - Deformarea geometrica a trasaturilor
    - Cantitatea de riduri provocata
  - **Dinamica** - in general detectia pe imagini statice este dificila
- O expresie are fazele:
  - Instalarea (onset)
  - Sustinerea (apex)
  - Relaxarea (offset)



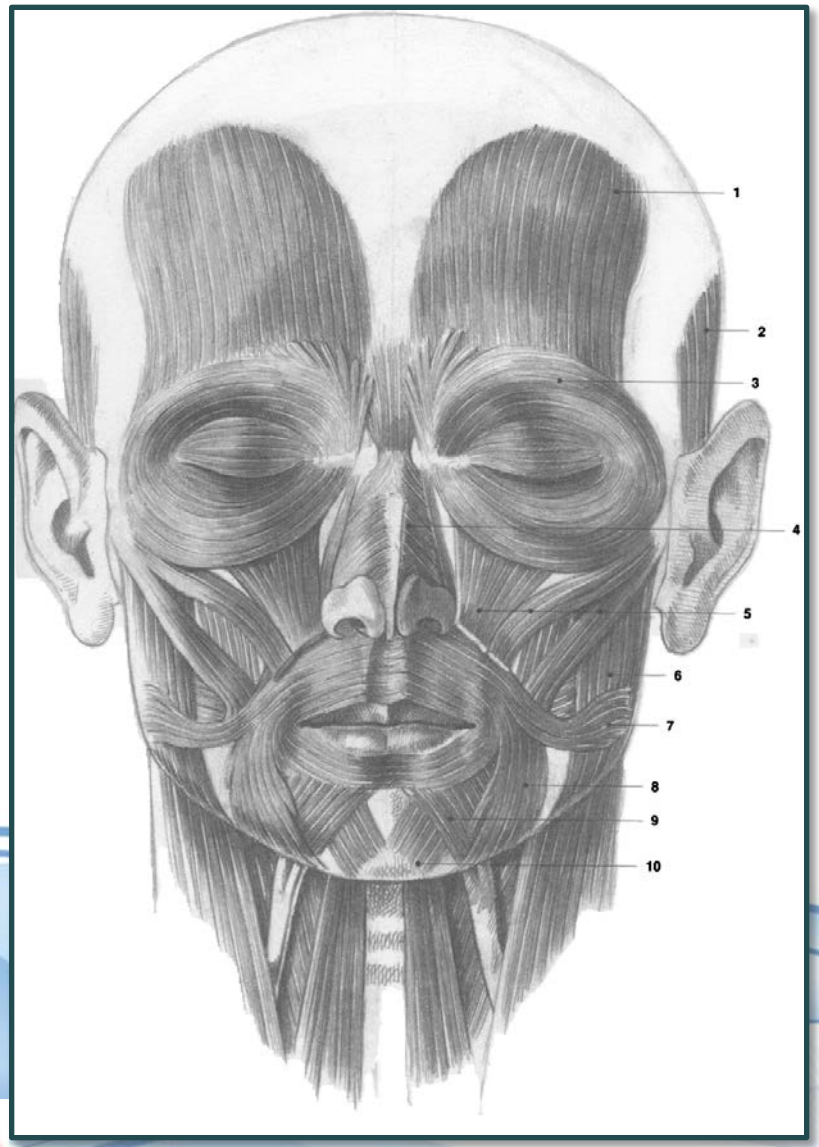
Dinamica trasaturilor

- Trasaturile fetei sunt:
  - Trecatoare :
    - Descriu emotiile
    - Localizate in jurul ochilor, sprancenelor, gurii, pometilor
  - Permanente
    - De ex: parul, cicatrici, textura pielii
- Deformarea trasaturilor trecatoare releva emotiile

Emotiile si expresiile sunt **dinamice**

Baseline – neutru ar ajuta

Muschii fetei



- Miscarile unui anumit muschi al fetei determina aparitia unei anumite trasaturi.
- O trasatura participa la formarea unei expresii - emotii

FACS

- **Facial Action Coding System** propus de catre Ekman si Friesen - 1976
- Descrie un set de 46 ‘Unitati de Actiune’ (Action Units - AU) ce corespund miscarilor elementare (independente) ale muschilor fetei
  - Unele corespund unui singur muschi
  - Majoritatea implica un set de muschi sau o miscare complexa
- Se refera la **miscare** (nu pozitii statice).

FACS – exemple AU

Example:

1. Interiorul sprancenei se ridica (Frontalis, Pars Medialis)
2. Exteriorul sprancenei se ridica (Frontalis, Pars Lateralis)

17. Barbia se ridica (Mentalis)
19. Limba scoasa
20. Buza se intinde (Risoris)
29. Mandibula iesita in afara
30. Mandibula in lateral
31. Falca inclestata

AU in expresii

- Expresiile faciale sunt constituite din unitatile de actiune de baza
- Ex: **Fericirea**:

  1. Interiorul sprancenei se ridica (Frontalis, Pars Medialis)

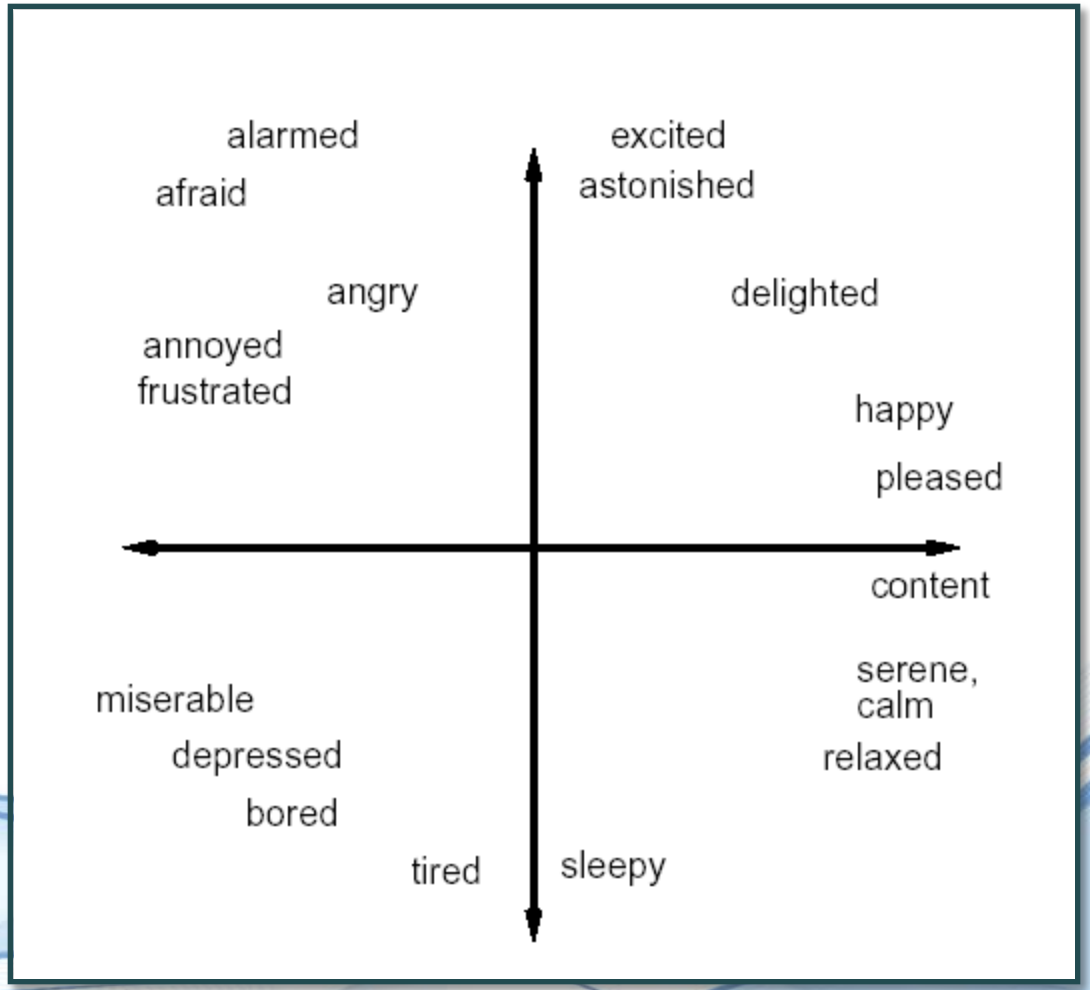
  6. Pometele se ridica (Orbicularis Oculi, Pars Orbitalis)

  12. Coltul buzei se ridica (Zygomatic Major)

  14. Riduri la coltul gurii (Buccinator)

Axele Emotionale

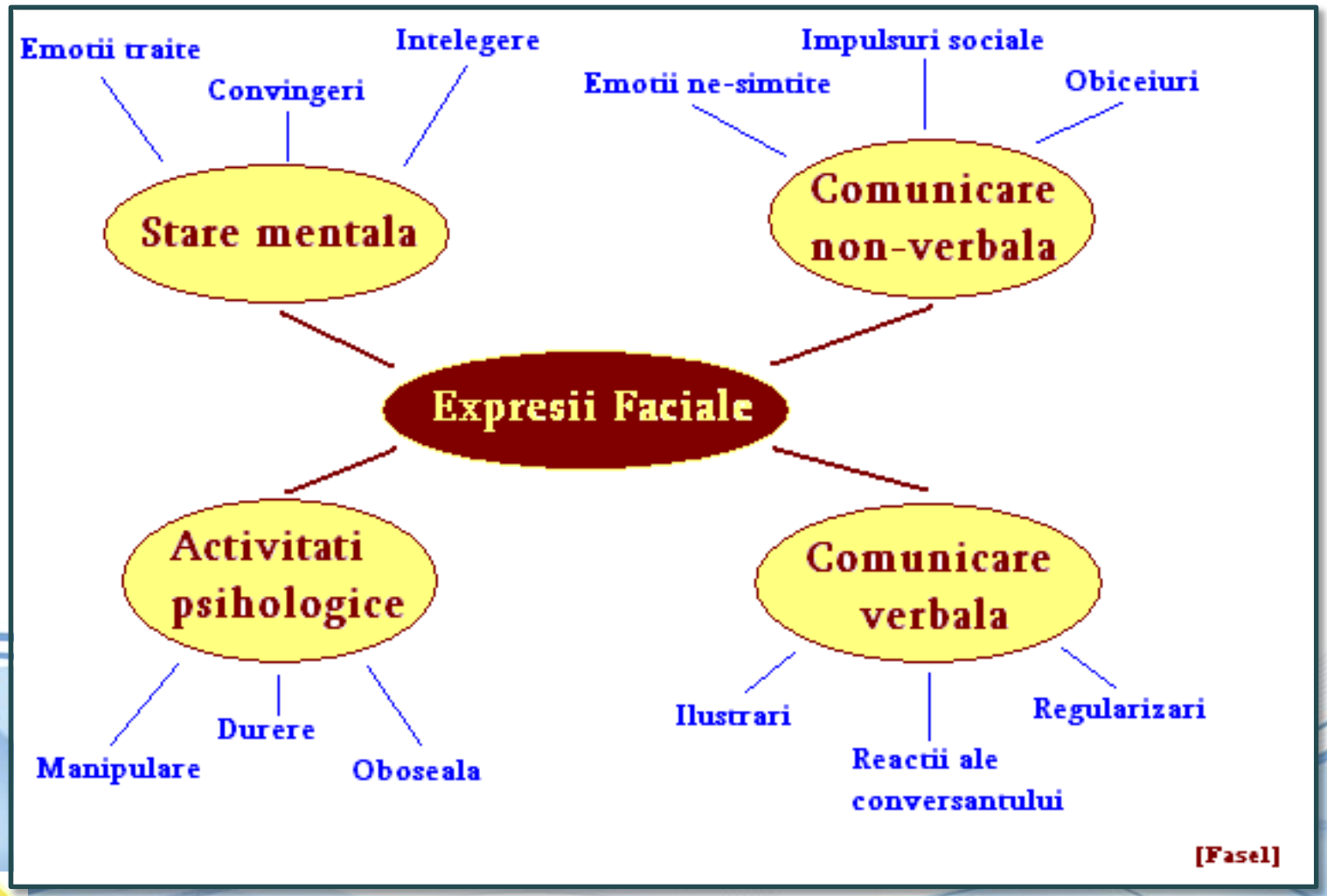
- Starile emotionale pot fi reprezentate pe un sistem cu doua coordonate:
- X = Fericit / Trist
- Y = Excitat / Relaxat



Date de test

- Baze de date existente:
  - Cohn-Kanade – adnotata de experti
  - Cohn-Kanade+ – adnotata prin consens
  - MMI
  - UNBC Mc Master (durere), Bio-Heat-Vid (durere)
  - Etc.
- Baze de date proprii:
  - Expresii simulate
  - Utilizarea unui actor pentru simularea expresiilor
  - Inducerea unei emotii

Producerea expresiilor



Inducerea emotiilor

Tristete:

- Poveste care evocă simpatia spusa pe un ton atragator (plangacios) al vocii;
- Muzică de fundal trista;
- Jucărie cu aspect sumbru;
- Iluminare albastra

Furie:

- Poveste care subiecţii sunt inselati spusa pe un ton sarcastic;
- Jucărie cu aspect neplăcut;
- Iluminare rosie

Surpriză:

- Creşterea bruscă a volumului de muzica de fundal,
- Un sunet intermitent de sonerie şi de sticlă sparta

Problema: Estimare Intensitatii Durerii

No Pain			
Pain			

The Prkachin – Solomon Pain Score (PSPI)

Pain = AU4 + max (AU6,AU7) + max (AU9,AU10) + AU43

AU4- Brow Lowerer



AU6 - Cheek Raiser



AU9 - Nose Wrinkler



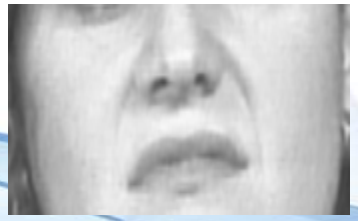
AU43- Eyes Closed



AU7 - Lid Tightener



AU10 - Upper Lip Raiser



K. Prkachin, P. P. Solomon, The structure, reliability and validity of pain expression: Evidence from patients with shoulder pain, Pain 139 (2008) 267–274.
http://www.cs.cmu.edu/~face/facs.htm

Probleme conexe:Microexpresii



- Foarte scurte: 1/25 secunde
- Mereu veridice
- Sunt considerate “leakage” cand se incearca ascunderea unei emotii

Metode de analiza

- Analiza miscarii faciale
  - Se analizeaza secvente video – flux optic
- Potrivirea unui model
  - Se genereaza un model artificial al fetei cu diferite expresii
- Abordarii bazate pe extragere de trasaturi
- Abordari holistice
  - Fata este un intreg indivizibil si nereprezentabil prin trasaturi

Detectia AU prin analiza fluxului optic

- FACS si AU se refera la miscare – secventa video
- Diferenta intre doua cadre este data de fluxul optic
- Reprezentare completa de texturi şi miscari din imagini
  - Mai fiabil decât masurarea intesitatii trasaturilor specifice, intensificarea ridurilor
- Exemple:
  - **[Yacoob]** - reprezentarea miscarii faciale prin analiza fluxului optic, constand din descrieri de tipul ”*coltul dreapta al gurii se ridică”*.
  - [**Beymer**] – antrenat reţele neuronale pentru face asocieri flux optic - expresii

[Donato]

Fluxul optic

- Estimarea locala a miscarii din imagine.
- Metode:
  - Minimizarea ecuatiei conservarii intensitatii luminoase, cu constrangeri

$$I(x, y, t) = I(x + \partial x, y + \partial y, t + \partial t) \Rightarrow \frac{\partial I}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial I}{\partial y}\frac{\partial y}{\partial t} + \frac{\partial I}{\partial t}\frac{\partial t}{\partial t} = 0$$

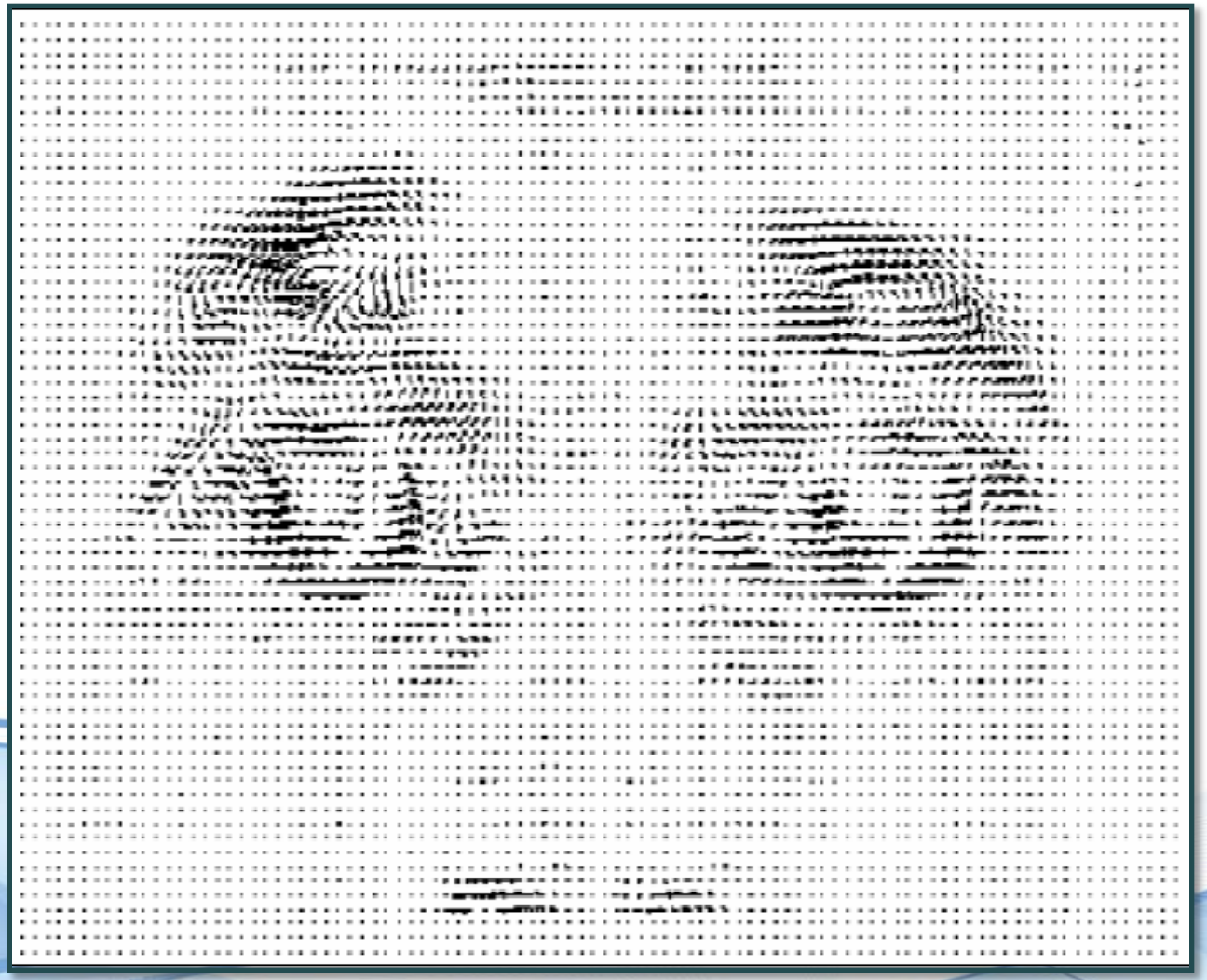
Solutii:

- **Horn & Schunk**, 1981 - variatia fluxului este lina
- **Lucas & Kanade** 1981- fluxul este constant pe zone mici
- **Maximul fazei** (metoda spectrala)

  - Block Matching Method

[Donato]

Fluxul optic



[Donato]

Subject performing AU 1

Clasificarea cu fluxul optic

Procedura de clasificare:

• Fiecare algoritm de analiza a imaginilor produce un vector de caracteristici, ***X***.

• Clasificatorul:

- •Pe baza regulii celui mai apropiat vecin
- •Template matching

•Masura de similaritate:

- •Cosinus (unghiul dintre doi vectori):

$$d(X_1, X_2) = \angle(X_1, X_2) = \arccos\left(\frac{\langle X_1, X_2 \rangle}{\|X_1\| \cdot \|X_2\|}\right)$$

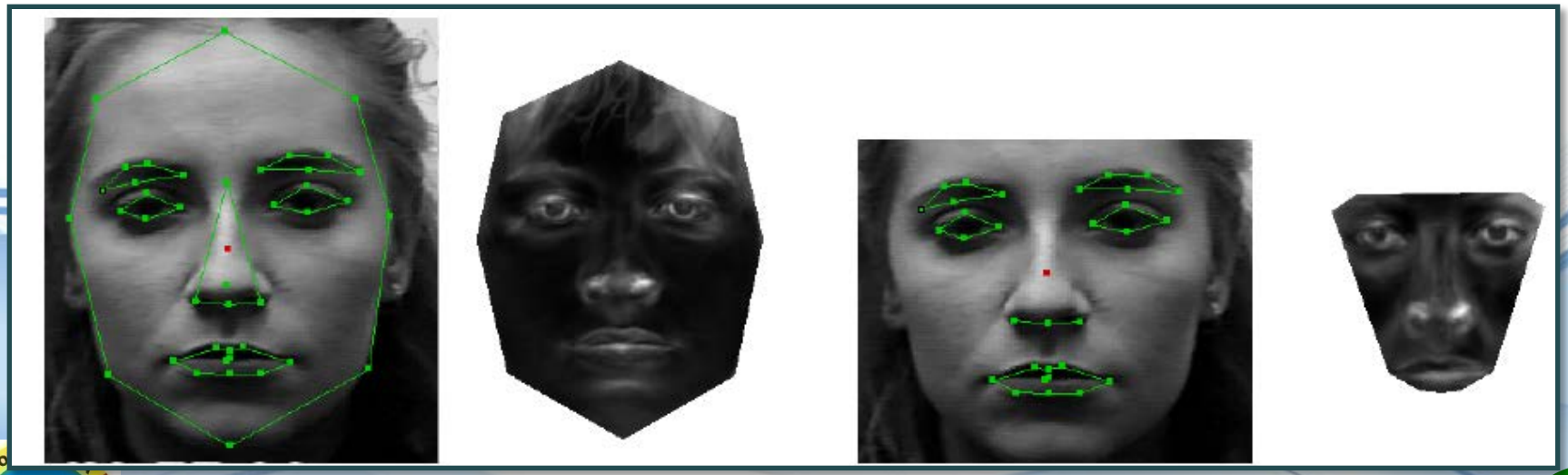
- •Distanta euclidiana.

• Netezirea hartii de variatie degradeaza performanţa;

- • Este necesar sa avem un flux de rezoluţie spaţială mare

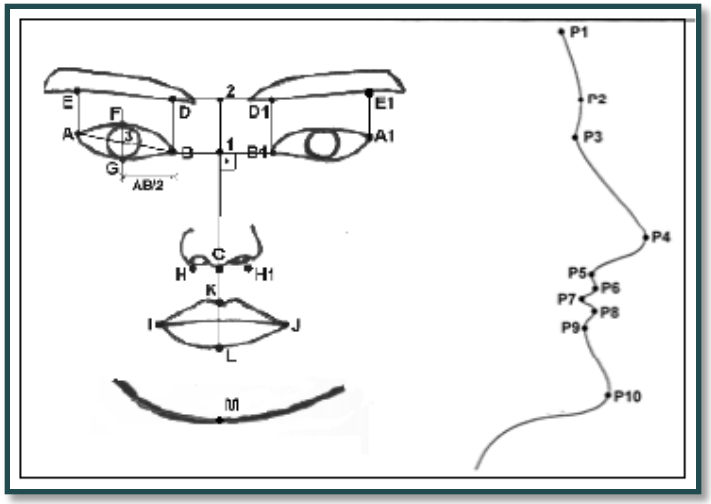
Abordari bazate pe extragerea de trasaturi

- Ideea: expresiile sunt determinate prin analiza unor zone localizate de pe fata
- Trasaturile se deformeaza fata de pozitia neutra
- Modele deformabile ale trasaturilor - AAM



Extragerea de trasaturi - solutii

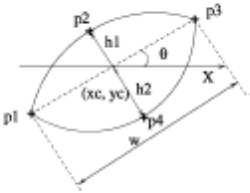
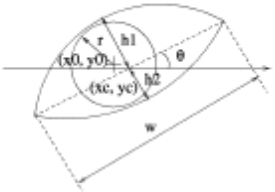
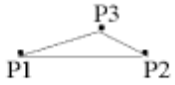
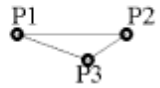
- **[Pantic]:**
  - Detectia fetei si a trasaturilor pe baza unei cascade de clasificatori:
    - Contururi active
    - Retele neurale
  - Masuratori geometrice din puncte de control de pe conturul sprancenelor, ochilor, narilor, gurii si barbiei



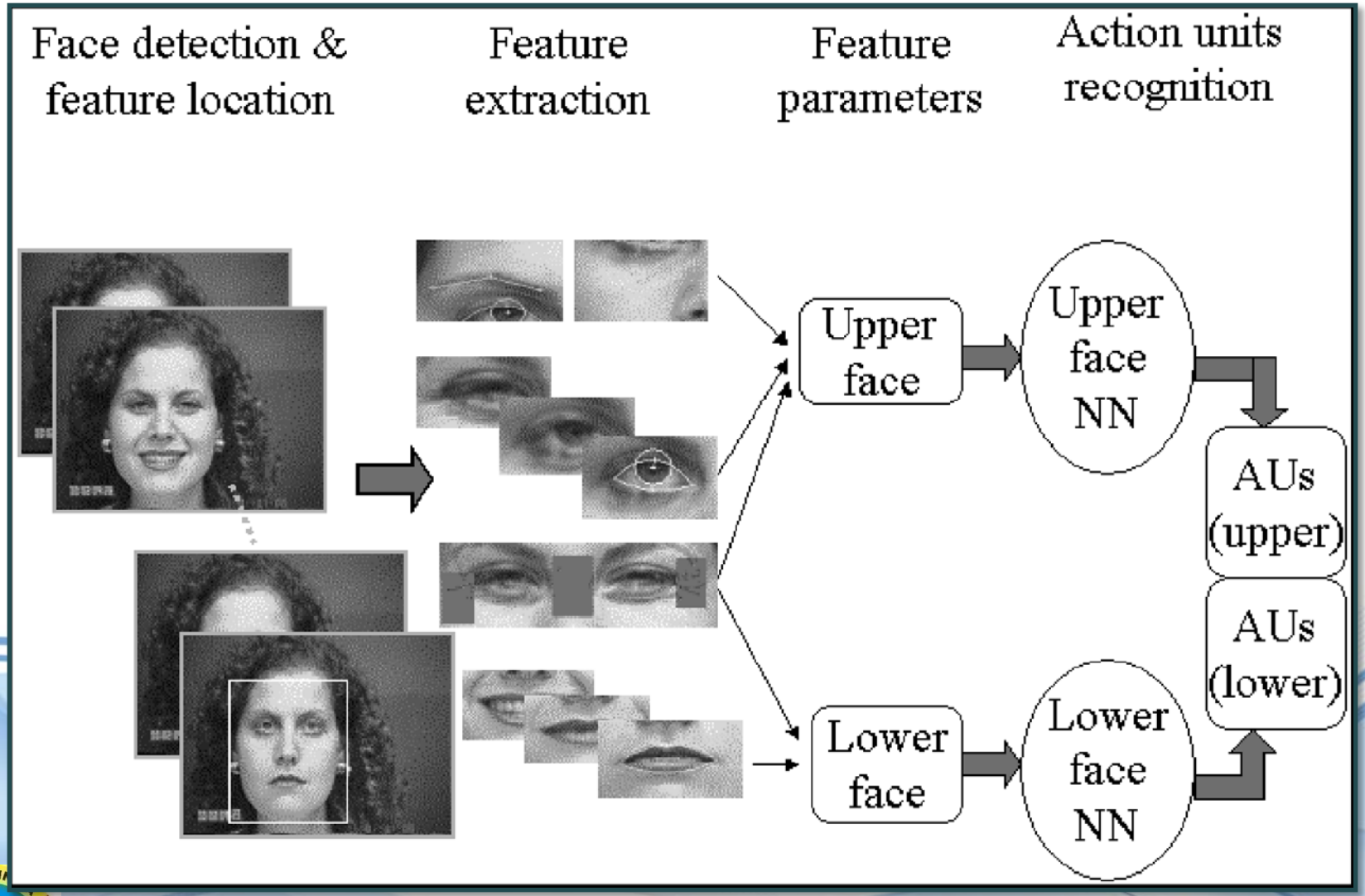
  - **Clasificator**: sistem expert bazat pe reguli pentru o ierarhie de clasificare cu două etape: codarea datelor geometrice în AU, urmată de clasificare în prototipuri expresie de bază

Extragerea de trasaturi - solutii

- [Tian]:
  - Segmentarea fetei si a trasaturilor care se modifica utilizand:
    - Amestecuri gaussiene – culoarea buzelor
    - Lukas Kanade pentru sprancene
    - Detectorul Canny pentru contururi
  - Reprezentare discreta si continua pentru fiecare AU, pe baza unui model
  - Clasificator: utilizaeaza un perceptron multi strat pentru partea superioara, respectiv pentru partea inferioara

Component	State	Description/Feature
Lip	Open	
	Closed	
	Tightly closed	
Eye	Open	
	Closed	
Brow	Present	
Cheek	Present	

Extragerea de trasaturi - solutii

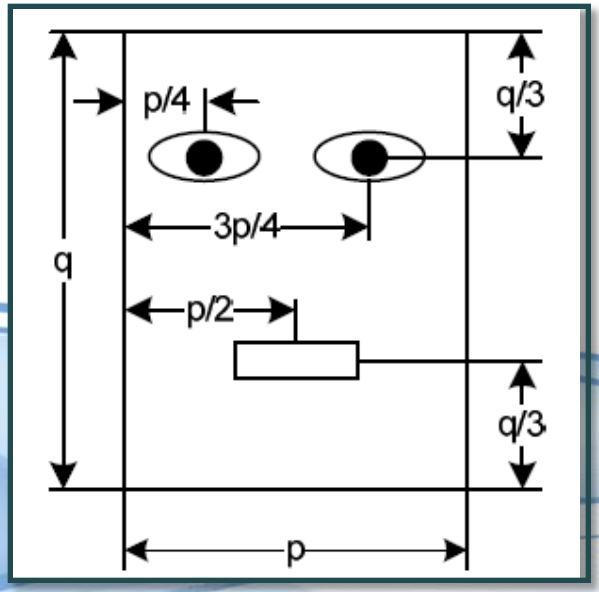


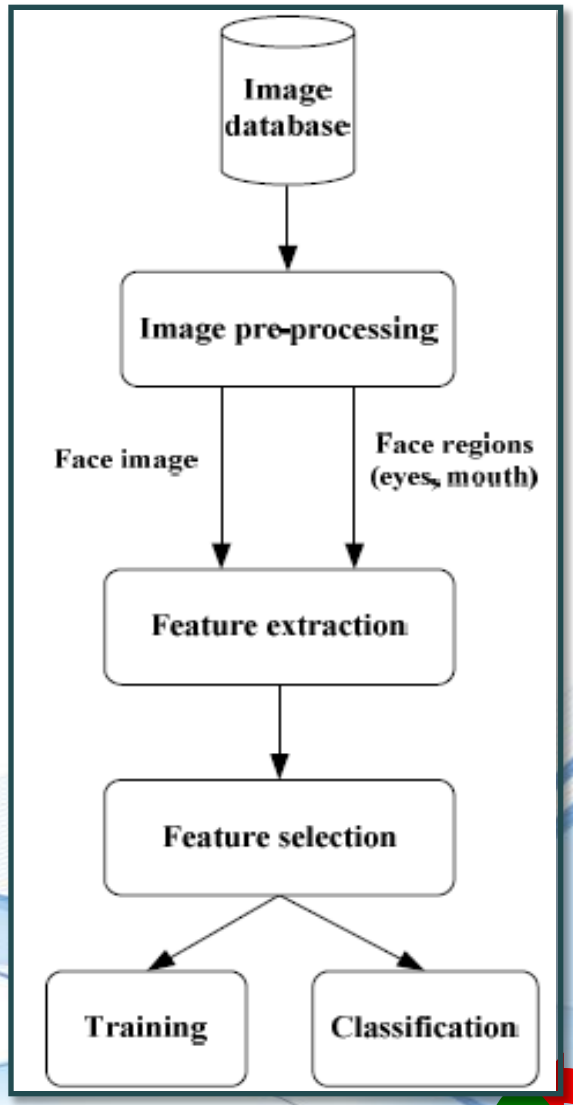
[Tian]:

Extragerea de trasaturi - solutii

[Lajevardi]:

- Segmentare geometrica a fetei
- Trasaturi:
  - forma logaritmica a filtrelor Gabor
  - Selectate pe baza informatiei mutuale
- Clasificator naiv de tip Bayes





Extragerea de trasaturi - solutii

[Peng]:

- Extragere de trasaturi de tip Haar
- Codare similara cu LBP
- Clasificator de tip AdaBoost pentru fiecare emotie

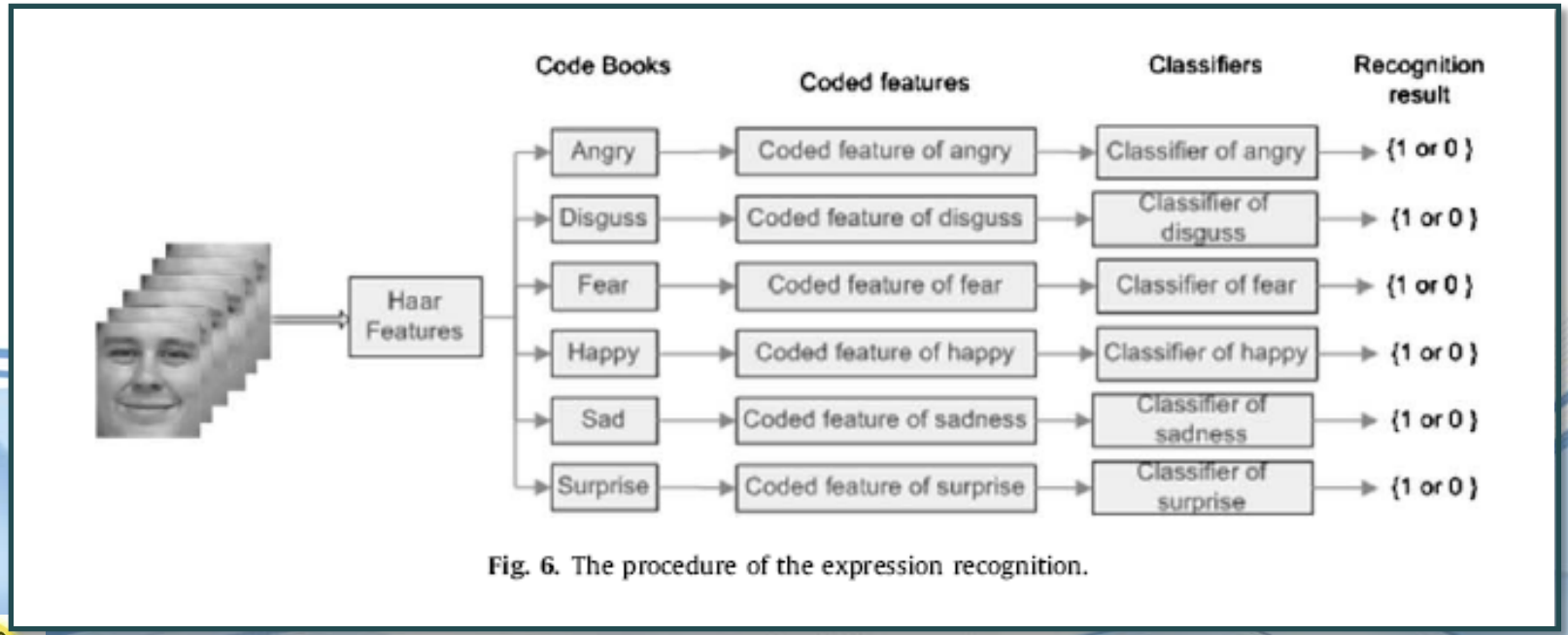


Fig. 6. The procedure of the expression recognition.

Extragerea de trasaturi - solutii

[Isukapalli]:

- Extragere de trasaturi de tip Haar
- Trasturile sunt ordonate in arbori de decizie (DTC – decision tree of classifiers)
- Aranjarea permite ca in functie de rezultatul la un nivel sa se decida care este clasificatorul la nivelul urmator
    - Solutia clasica: aceeasi cascada se aplica de fiecare data

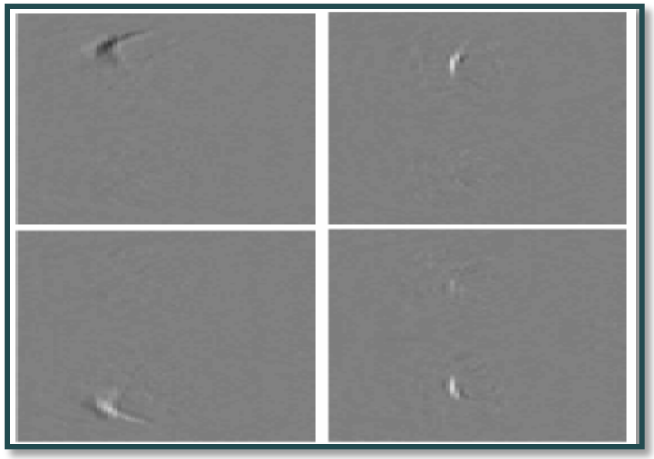
Analiza holistica

- Imaginile originale sunt considerate a fi unitare.
- Clasificatorul este cel care decide ce este relevant
- Configuratia trasaturilor sau formele sunt dificil de parametrizat
- Solutii:
  - PCA – Principal Component Analysis
  - LFA - Local Feature Analysis
  - LDA – Linear Discriminant Analysis
  - ICA – Independent Component Analysis

PCA pentru emotii

- Portretul este divizat in:
  - Partea superioara
  - Partea inferioara
- Se aplica PCA pe fiecare pentru extragerea dimensiunilor celor mai relevante
- Dimensiunea este redusa la ~ 30 componente
- Clasificarea este realizata pe baza:
  - Celui mai apropiat vecin
  - Template Matching (maximizarea similaritatii)

ICA pentru emotii



- Ca si la PCA :
  - Partea superioara
  - Partea inferioara
- Se prefiltreaza cu Gabor
- Se aplica ICA pe fiecare pentru determinarea surselor independente
- Dimensiunea este redusa la ~ 75 componente
- Clasificarea este realizata pe baza:
  - Celui mai apropiat vecin
  - Template Matching (maximizarea similaritatii)

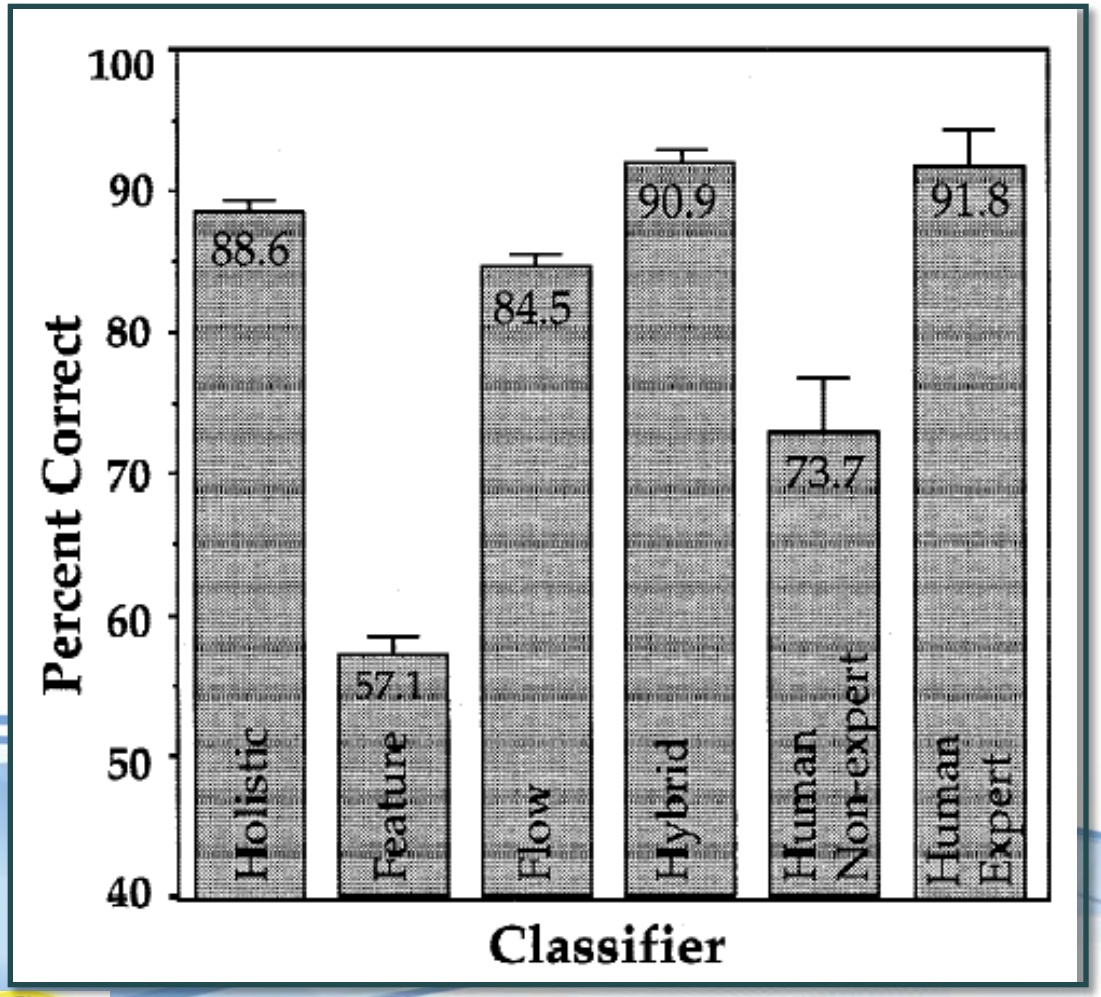
[Donato]

ICA cu Gabor pentru emotii

[Buciu]

- Se utilizeaza filtre Gabor pentru extragere de trasaturi locale.
  - Normalizeaza imaginea
- Se aplica ICA pe fiecare pentru determinarea surselor independente:
  - Se cauta elemente sub-Gaussiene
  - Trasaturile sunt independente
  - Pixelii sunt independenti

Rezultate obtinute



Observatori umani ne-antrenati au performante mai slabe decat metode automate de clasificare

[Bartlett]

Rezultate obtinute

Optic Flow	Correlation	85.6% ± 3.3
	Smoothed	53.1% ± 4.7
Holistic Spatial Analysis	PCA	79.3% ± 3.9
	LFA	81.1% ± 3.7
	FLD	75.7% ± 4.1
	ICA	95.5% ± 2.0
Local Spatial Analysis	Gaussian Kernel	70.3 ± 4.
	PCA Shift-inv	73.4% ± 4.2
	PCA Shift-var	78.3% ± 3.9
	PCA Jets	72.1% ± 4.2
	Gabor Jets	95.5% ± 2.0

Human Subjects	Naive	77.9% ± 2.5
	Expert	94.1% ±2.1

[Donato]

Rezultate obtinute

Authors	# Subjects		# Faces		# FACS	Extraction	Classification	Rec.
	Test	Train	Test	Train	AUs	Methods	Methods	Rate
	4-20	4-20	111*5	111*5	$6^a + 6^b$	Diff-Img.+G. Jets	Near. Neigh.	**96%**
Bartlett [2]	4-20	4-20	111*5	111*5	$6^a + 6^b$	Diff. Img.	ICA+N. Neigh.	**96%**
	4-20	4-20	111*5	111*5	$6^a + 6^b$	Optical Flow	Motion Templ.	**86%**
Fasel [34]	1	1	45	182	9^c	Diff.-Img.	ICA+Eucl. Dist.	**83/41%**
Cohn [14]	30	N/A	N/A	N/A	**15**	Feat. Point Track.	HMM	**86%**
	N/A	N/A	75*20	60*20	3^a	Feat. Point Track.	HMM	**85%**
	N/A	N/A	150*20	120*20	6^b	Feat. Point Track.	HMM	**88%**
Lien [53]	N/A	N/A	75*20	44*20	3^a	Optical Flow	PCA+HMM	**93%**
	N/A	N/A	160*20	100*20	4^a	High Grad. Comp.	HMM	**85%**
	N/A	N/A	80*20	50*20	2^b	High Grad. Comp.	HMM	**81%**
Pantic [68]	8	N/A	496	N/A	**31**	Multi Feat. Detect.	Expert Rules	**89%**

Table 2: **Selected Facial Expression Recognition Systems:** Classification of Facial Actions using FACS. ^{a}Upper-Face FACS coding. ^{b}Lower-Face FACS coding. ^{c}Nine asymmetric FACS classes, each with 5 intensity levels on 2 face sides.

[Fasel]

Rezultate obtinute

Authors	# Subjects		# Faces		# Em.	Extraction	Classification	Rec.
	Test	Train	Test	Train	Class.	Methods	Methods	Rate
Lyons [56]	9	N/A	193	N/A	**7**	G.Wav.+El.Gr.	LDA+PCA+Cl.	**75-92%**
Kobayashi [49]	15	N/A	90	N/A	**6**	-	Feed Forw. NN	**85%**
Rosenblum [72]	32	20/14	34 sq.	20/14 sq.	**2**	Optical Flow	RBF NN	**88%**
Padgett [66]	12	N/A	N/A	N/A	**6**	-	PCA + NN	**86%**
Essa [33]	8	8	8 sq.	8 sq.	**6**	Opt.F.+3D M.	Motion Templ.	**98%**
Lanitis [51]	30	30	300	390	**7**	Appear. Mod.	Mahal. Distance	**74%**
Black [9]	40	N/A	70 sq.	N/A	**6**	Motion Mod.	Expert Rules	**83-100%**
Pantic [68]	8	N/A	496	N/A	**6**	Mul. Feat. Det.	Expert Rules	**91%**

Table 3: **Selected Facial Expression Interpretation Systems:** Classification of Emotional Displays. Note that the systems presented in the last two rows perform facial action recognition prior to using dictionaries in order to interpret facial actions.

[Fasel]

Ce trebuie tinut minte din cursul de fata

Emotii/expresii – punerea problemei:

- Care sunt expresiile fundamentale? Dar cele derivate?
- Sunt expresiile fundamentale usor de separat?
- Proprietatile trasaturilor care descriu expresiile: faze, dinamicitate, transienta

Solutii:

- Care sunt metodele generale
  - Fluxul optic:
    - ce e, care sunt metodele clasice, cum se aplica pentru recunoasterea de emotii.
  - Abordari bazate pe caracteristici
    - principii generale, etape ale algoritmilor
  - Abordari holistice
    - principii generale, etape ale algoritmilor

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Multumesc pentru atentie!

In ceea ce priveste intrebarile… va ascult