Lecture-10

Recognizing Facial Expressions

- Facial expressions reflect the emotional stage of a person.
- Recognizing facial expression from video sequences is a challenging problem.
- Applications
  - Perceptual user interface
  - Video compression (MPEG-4)
  - Synthesis of facial expression

Facial Expressions

- Joy
  - The eyebrows are relaxed. The mouth is open, and mouth corners pulled back toward ears.
- Sadness
  - The inner eyebrows are bent upward. The eyes are slightly closed. The mouth is relaxed.
- Anger
  - The inner eyebrows are pulled downward and together. The eyes are wide open. The lips are pressed against each other or opened to expose teeth.

Facial Expressions

- Fear
  - The eyebrows are raised and pulled together. The inner eyebrows are bent upward. The eyes are tense and alert.
- Disgust
  - The eyebrows and eyelids are relaxed. The upper lip is raised and curled, often asymmetrically.
- Surprise
  - The eyebrows are raised. The upper eyelids are wide open, the lower relaxed. The jaw is open.

FACIAL EXPRESSIONS

RAISE EYE BROWS

SMILE

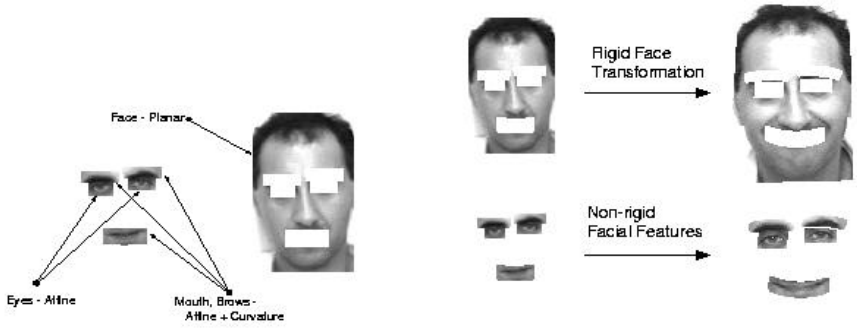
FACIAL EXPRESSIONS

DISGUST

ANGER

Black and Yacoob Algorithm

- Given the location of the face, eyes, brows, and mouth estimate the rigid motion of the face using pseudo perspective motion model.
- Use the face motion to register images through warping.
- Estimate relative motion of face features (eyes, mouth, brows).
- The estimated feature motions are used to predict locations of features in the next frame, and the process is repeated.
- The estimated motion is used to classify the facial expressions.



Affine

$$u(x,y) = a_1 x + a_2 y + b_1$$
$$v(x,y) = a_3 x + a_4 y + b_2$$

$$\begin{bmatrix} u(x,y) \\ v(x,y) \end{bmatrix} = \begin{bmatrix} x & y & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x & y & 1 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ b_1 \\ a_3 \\ a_4 \\ b_2 \end{bmatrix}$$

Affine

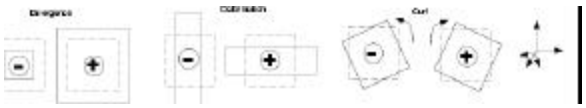
$$u(x, y) = a_1 x + a_2 y + b_1$$

$$v(x, y) = a_3 x + a_4 y + b_2$$

Expansion or contraction: $divergence = u_x + v_y = a_1 + a_4$

Rotation around Z: $curl = -(u_y - v_x) = -(a_2 - a_3)$

Squashing or stretching: $deformation = (u_x - v_y) = (a_1 - a_4)$



Pseudo Perspective

$$u(x, y) = a_1 + a_2 x + a_3 y + a_4 x^2 + a_5 xy$$

$$v(x, y) = a_6 + a_7 x + a_8 y + a_4 xy + a_5 y^2$$

a_4=yaw: rotation around y-axis

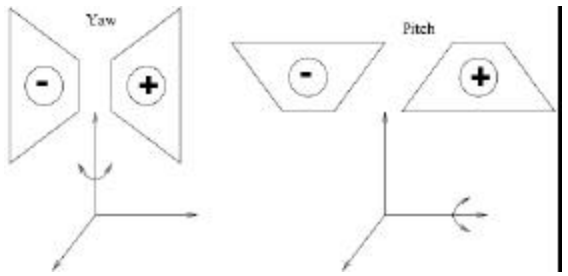
a_5=pitch: rotation around x-axis

$$\begin{bmatrix} u(x,y) \\ v(x,y) \end{bmatrix} = \begin{bmatrix} 1 & x & y & x^2 & xy & 0 & 0 & 0 \\ 0 & 0 & 0 & xy & y^2 & 1 & x & y \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \\ a_6 \\ a_7 \\ a_8 \end{bmatrix}$$

Pseudo Perspective

$$u(x, y) = a_1 + a_2 x + a_3 y + a_4 x^2 + a_5 xy$$

$$v(x, y) = a_6 + a_7 x + a_8 y + a_4 xy \; + a_5 y^2$$



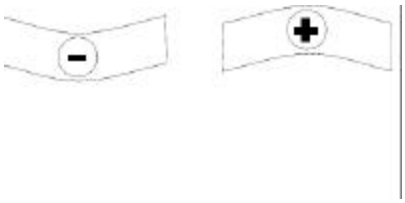
a_4=yaw
a_5=pitch

Affine with Curvature

$$u(x, y) = a_1 x + a_2 y + b_1$$

$$v(x, y) = a_3 x + a_4 y + b_2 + cx^2$$

$$\begin{bmatrix} u(x,y) \\ v(x,y) \end{bmatrix} = \begin{bmatrix} x & y & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & x & y & 1 & x^2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ b_1 \\ a_3 \\ a_4 \\ b_2 \\ c \end{bmatrix}$$



Rules for Classifying Expressions

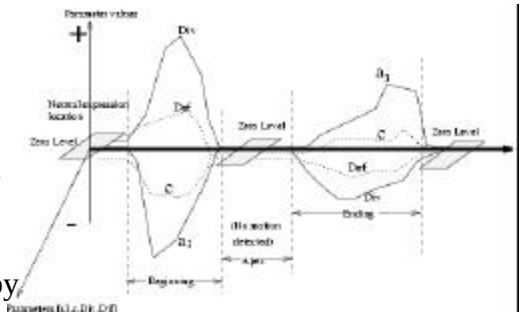
- Anger
  - B: inward lowering of brows and mouth contraction
  - E: outward raising of brows and mouth expansion
- Disgust
  - B: mouth horizontal expansion and lowering of brows
  - E: mouth contraction and raising of brows
- Happiness
  - B: upward curving of mouth and expansion or horizontal deformation
  - E: downward curving of mouth and contraction or horizontal deformation

Rules for Classifying Expressions

- Surprise
  - B: raising brows and vertical expansion of mouth
  - E: lowering brows and vertical contraction of mouth
- Sadness
  - B: downward curving of mouth and upward-inward motion in the inner parts of brows
  - E: upward curving of mouth and downward-outward motion in inner parts of brows
- Fear
  - B: expansion of mouth and raising-inwards inner parts of brows
  - E: contraction of mouth and lowering inner parts of brows

Smile Expression

Upward-outward motion of mouth corners results in –ve curvature
Horizontal and overall vertical stretching result in +ve div & def.
Some upward trans is caused by raising of lower and upper lips due to stretching of the mouth (a3 is –ve).



Smile

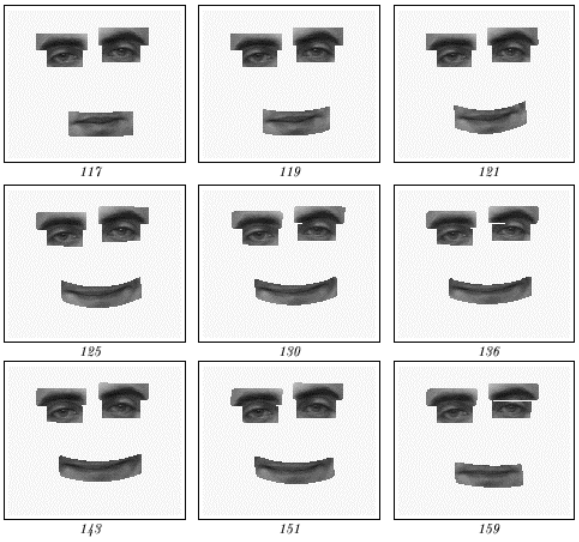


Figure 8: Smile experiment: facial expression tracking.

Smile Mouth Parameters

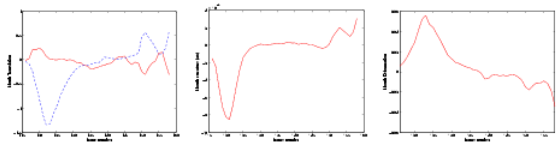


Figure 9: Smile mouth parameters. For translation, solid and dashed lines indicate horizonta
and vertical motion respectively.

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Anger

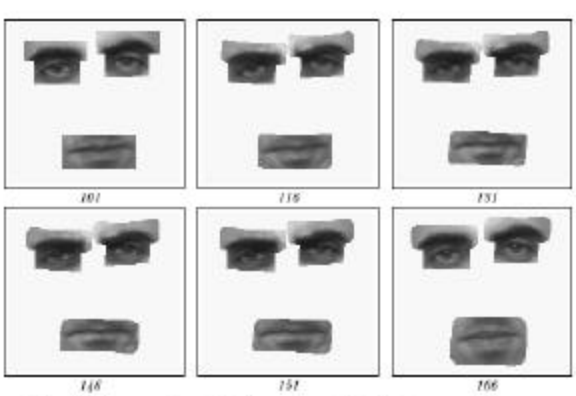


Figure 10: Anger experiment: facial expression tracking. Features every 15 frames.

Anger Motion Parameters

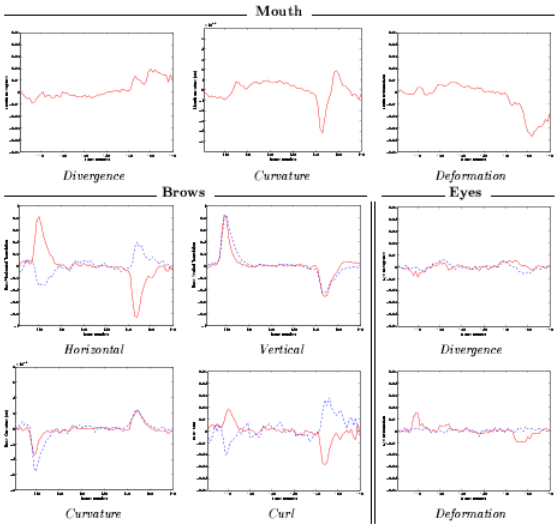
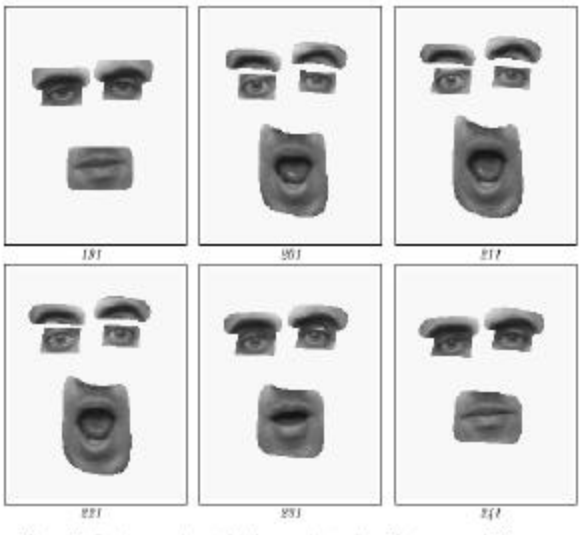
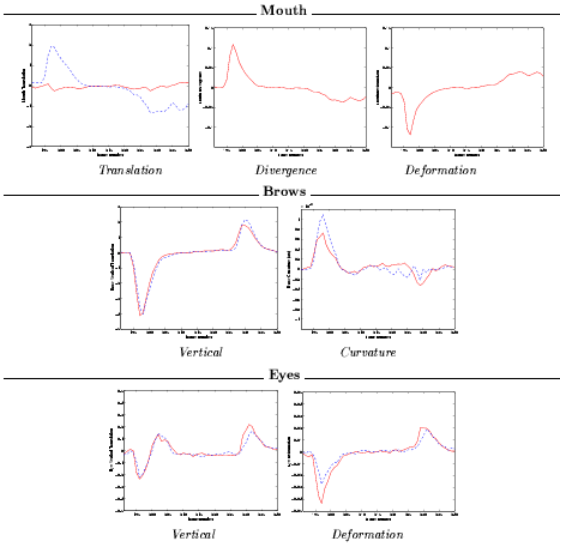


Figure 11: Anger motion parameters; the solid line indicates the right eye or brow while the dashed line indicates the left eye or brow.

Surprise



Surprise Motion Parameters



Blinking

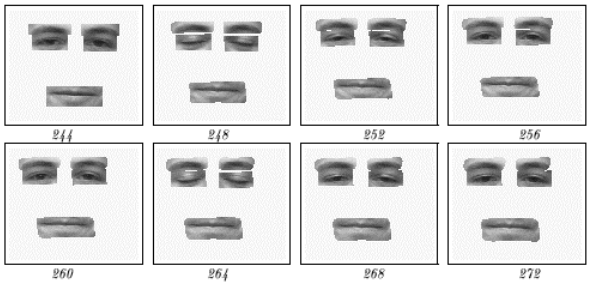
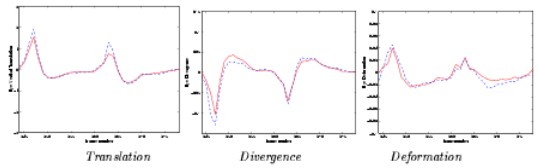
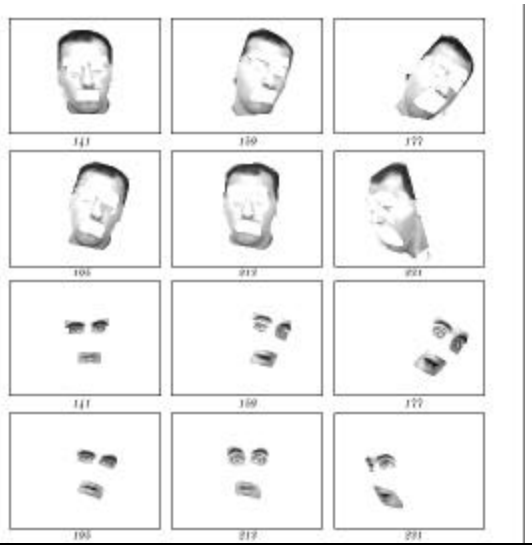


Figure 14: Blinking experiment: facial feature tracking. Features every four frames.

Blinking Motion Parameters for Eyes

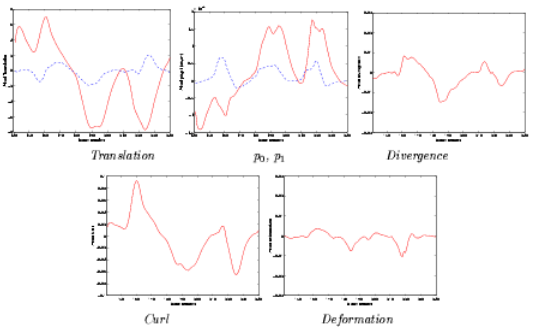


Rotation

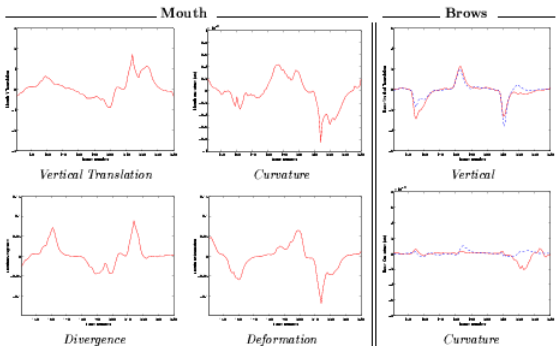


Rotate Face motion parameters

P_0 rot y
P_1 rot X



Rotation Motion Parameters



Mid-level predicates for Mouth

Table 3: The mid-level predicates derived from deformation and motion parameter estimates.

Parameter	Threshold	Derived Predicates
a_0	> 0.25	Mouth rightward
	< -0.25	Mouth leftward
a_1	< -0.1	Mouth upward
	> 0.1	Mouth downward
Div	> 0.02	Mouth expansion
	< -0.02	Mouth contraction
Def	> 0.005	Mouth horizontal deformation
	< -0.005	Mouth vertical deformation
Curl	> 0.005	Mouth clockwise rotation
	< -0.005	Mouth counterclockwise rotation
e	< -0.0001	Mouth curving upward ("U" like)
	> 0.0001	Mouth curving downward

Mid-level predicates for Head

Table 4: The mid-level predicates derived from deformation and motion parameter estimates as applied to head motion.

Parameter	Threshold	Derived Predicates
a_0	> 0.5	Head rightward
	< -0.5	Head leftward
a_1	< -0.5	Head upward
	> 0.5	Head downward
Div	> 0.01	Head expansion
	< -0.01	Head contraction
Def	> 0.01	Head horizontal deformation
	< -0.01	Head vertical deformation
Curl	> 0.005	Head clockwise rotation
	< -0.005	Head counterclockwise rotation
p_0	< -0.00005	Head rotating rightward around the neck
	> 0.00005	Head rotating leftward around the neck
p_1	< -0.00005	Head rotating forward
	> 0.00005	Head rotating backward

Parameter values used for classifying expressions

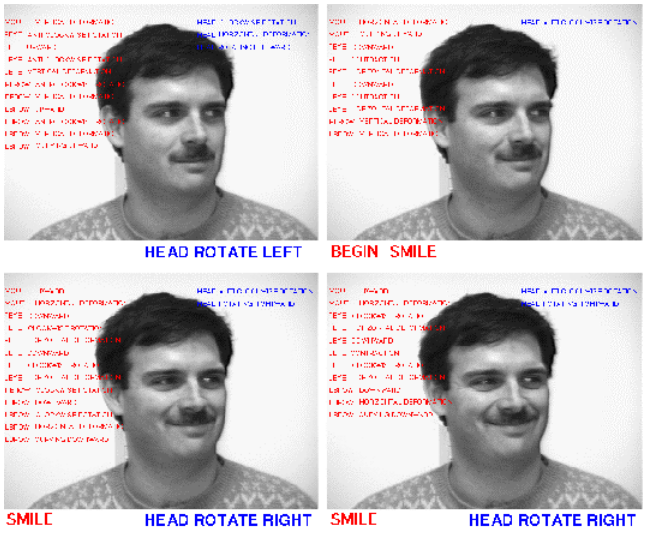
Expr.	R/E	Feature	a_N	a_L	Dir	Curl	Def	c
Anger	R	Mouth		–		0	+	–
		R. Brow	+	+		+	+	–
		L. Brow	–	+		–	+	–
		R. Eye	+		–		+	
		L. Eye			–		+	
Anger	E	Mouth		+		0	–	+
		R. Brow	–	–		–	–	+
		L. Brow	+	–		+	–	+
		R. Eye	–		+		–	
		L. Eye	+		+		–	
Happiness	R	Mouth		–			+	–
Happiness	E	Mouth		+			–	+
Surprise	R	Mouth		+	+	0	–	
		R. Brow	–	–		–		+
		L. Brow	+	–		+		+
		R. Eye	–	–	+		–	
		L. Eye	+	–	+			
Surprise	E	Mouth		–		0	+	
		R. Brow	+	+		+		–
		L. Brow	–	+		–		–
		R. Eye	+	+	–		+	
		L. Eye		+	–		+	

Forty Test Subjects

Results

Expression	Rate
Surprise	91%
Happiness	95%
Anger	90%
Disgust	93%
Fear	83%
Sadness	100%

Beginning of Anger Expression



Frames from 10 Video Clips

Results

Expression	Rate
Surprise	**86%**
Happiness	**95%**
Anger	**80%**
Disgust	**50%**
Fear	**100%**
Sadness	**60%**

http://www.cfar.umd.edu/ftp/TRs/CVL-Reports-1995/TR3401-Black.ps.gz