Recognizing Facial Expressions

Lecture-13

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Homework, Due November 11

- Lecture 9, slide 17, slide 22
- Lecture 12, page 21 and 22 (three problems).

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Program II, Due November 16

- Implement Mean shift Algorithm for tracking
  - Assume that the object location is given in the first frame of the seq
  - Demonstrate your program on known test seqs
  - Demonstrate your program on unknown test seqs in the lab
  - Write a short report: method, problems, results, observations.

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- 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 expressions

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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

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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.

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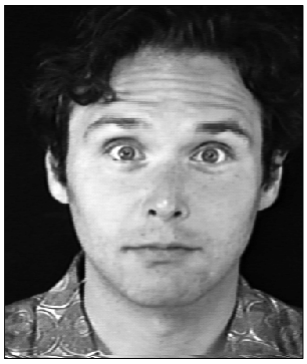
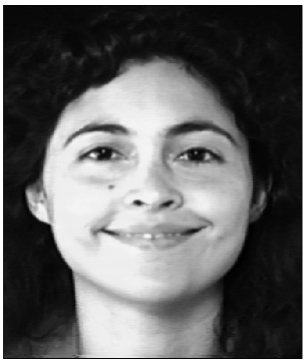
FACIAL EXPRESSIONS





RAISE EYE BROWS

SMILE

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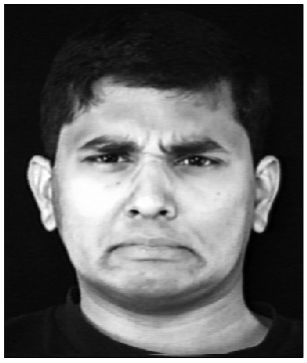
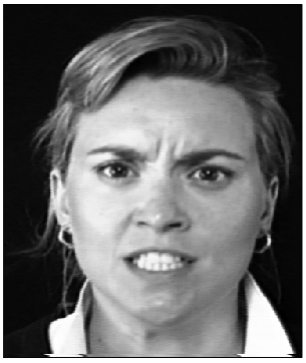
FACIAL EXPRESSIONS





DISGUST

ANGER

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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.

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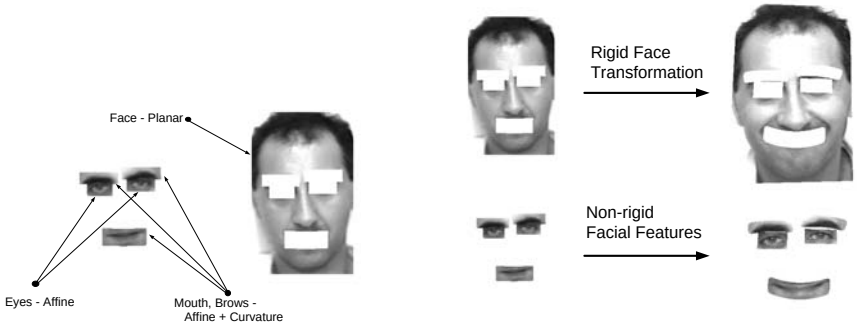

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Affine

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

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

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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: $deformation = (u_x - v_y) = (a_1 - a_4)$

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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

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

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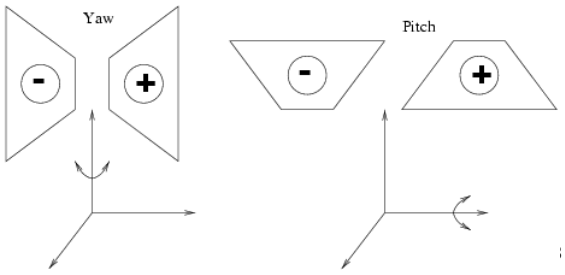
Pseudo Perspective

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

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



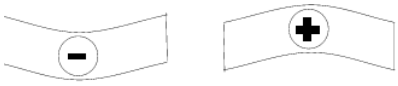
a_4=yaw
a_5=pitch

Affine with Curvature

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

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

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



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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

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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

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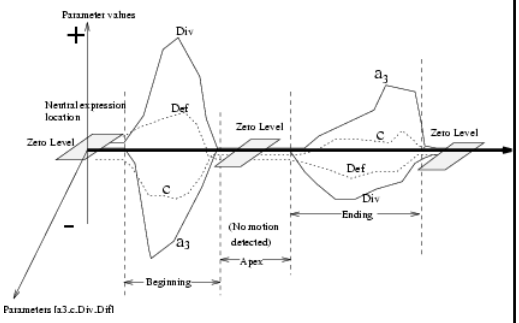
Smile Expression

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).



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Smile

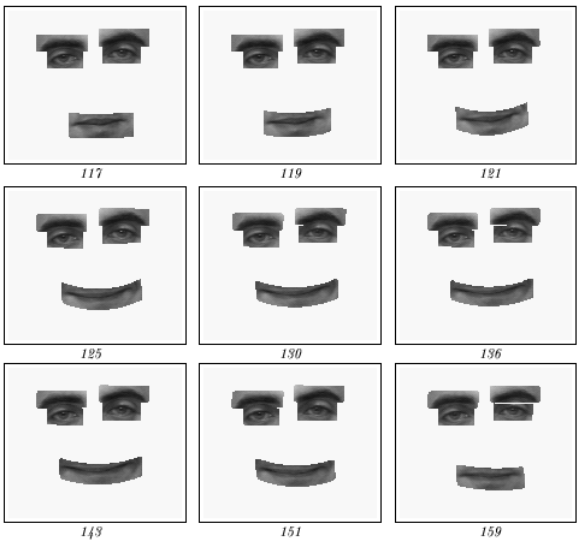

Figure 8: Smile experiment: facial expression tracking.

Smile Mouth Parameters

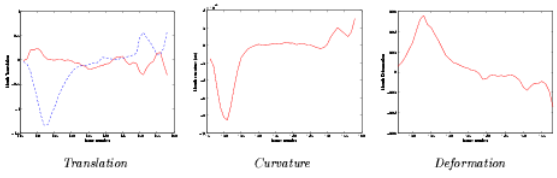

Figure 9: Smile mouth parameters. For translation, solid and dashed lines indicate horizonta
and vertical motion respectively.

16

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Anger

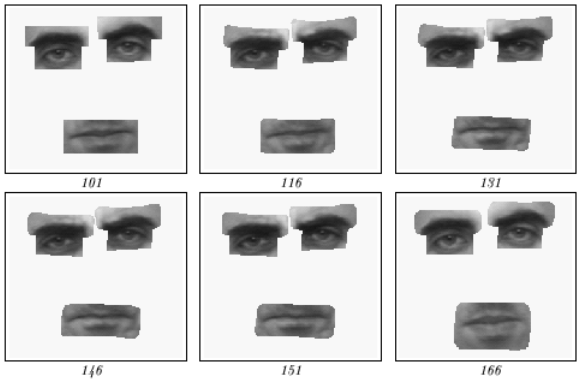

Figure 10: Anger experiment: facial expression tracking. Features every 15 frames.

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Anger Motion Parameters

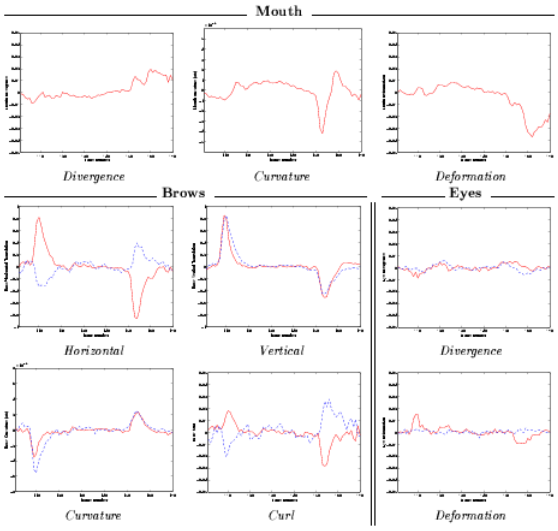
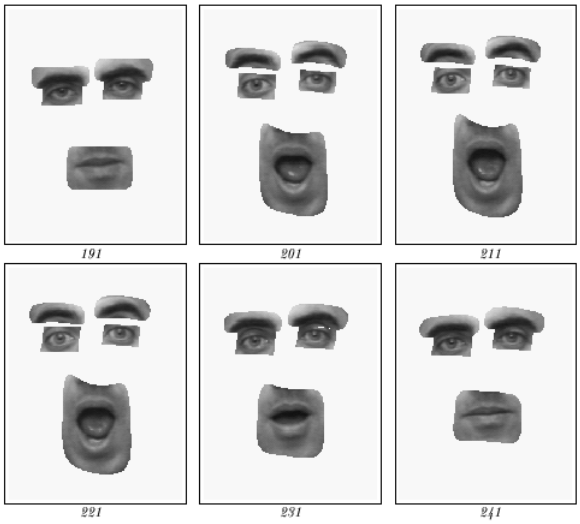
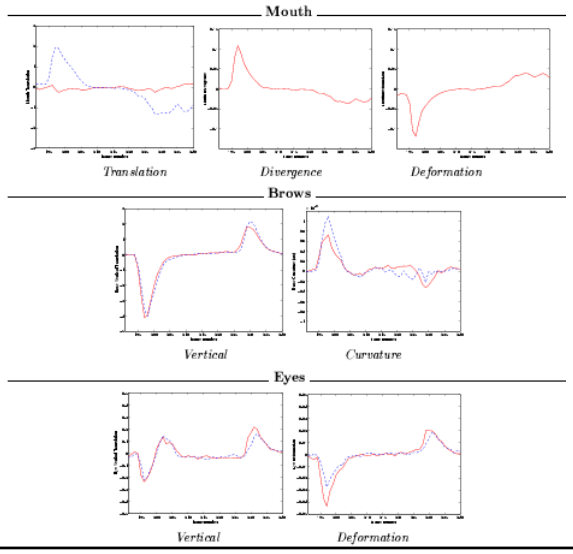


Figure 11: Anger motion parameters; the solid line indicates the right eye or brow while the dashed line indicates the left eye or brow.

Surprise



Surprise Motion Parameters



Blinking

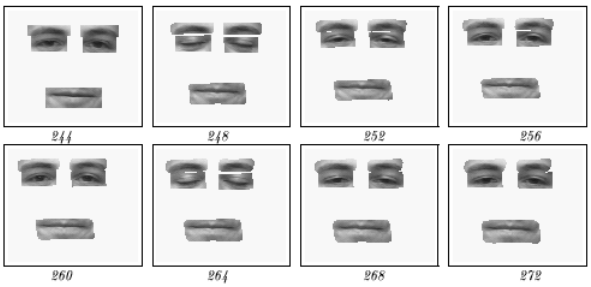


Figure 14: Blinking experiment: facial feature tracking. Features every four frames.

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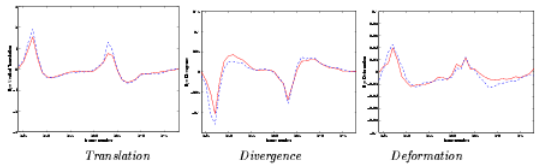
Blinking Motion Parameters for Eyes



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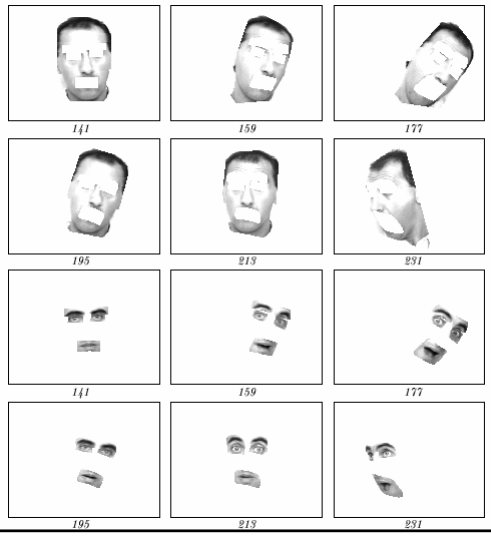
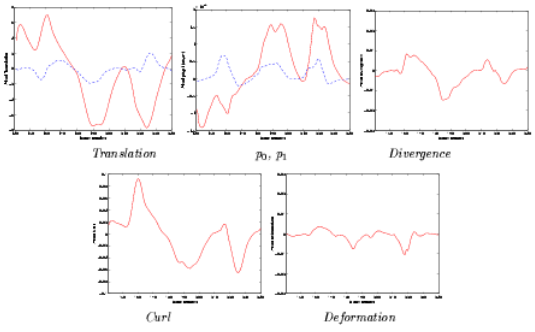
Rotation



Rotate Face motion parameters

P_0 rot y
P_1 rot X



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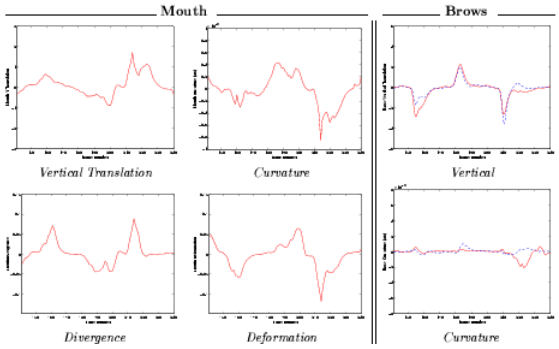
Rotation Motion Parameters



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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_3	< -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
c	< -0.0001	Mouth curving upward ('U' like)
	> 0.0001	Mouth curving downward

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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_3	< -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

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Parameter values used for classifying expressions

Expr.	B/E	Feature	a_0	a_3	Div	Curl	Def	c
Anger	B	Mouth		–		0	+	–
		R. Brow	+	+		+	+	–
		L. Brow	–	+		–	+	–
		R. Eye	+		–		+	
		L. Eye	–		–		+	
Anger	E	Mouth		+		0	–	+
		R. Brow	–	–		–	–	+
		L. Brow	+	–		+	–	+
		R. Eye	–		+		–	
		L. Eye	+		+		–	
Happiness	B	Mouth		–			+	–
Happiness	E	Mouth		+			–	+
Surprise	B	Mouth		+	+	0	–	
		R. Brow	–	–		–		+
		L. Brow	+	–		+		+
		R. Eye	–	–	+		–	
		L. Eye	+	–	+		–	
Surprise	E	Mouth		–	–	0	+	
		R. Brow	+	+		+		–
		L. Brow	–	+		–		–
		R. Eye	+	+	–		+	
		L. Eye	–	+	–		+	

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Forty Test Subjects

Results

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

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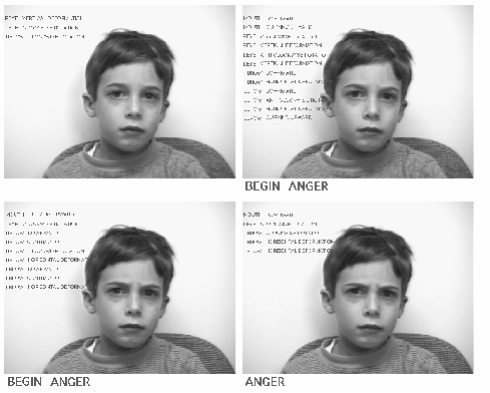
Beginning of Anger Expression



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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

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