Recognizing Facial Expressions

Lecture-12

- 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
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**

\[ u(x, y) = a_1 x + a_2 y + b_1 \]
\[ v(x, y) = a_3 x + a_4 y + b_2 \]

\[
\begin{bmatrix}
  u(x, y) \\
  v(x, y)
\end{bmatrix} =
\begin{bmatrix}
  a_1 \\
  a_2 \\
  b_1 \\
  a_3 \\
  a_4 \\
  b_2
\end{bmatrix}
\]

**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**

**Rotation around Z**

**Squashing or stretching**

*divergence*  \[= u_x + v_y = a_1 + a_4\]

*curl*  \[= -(u_y - v_x) = -(a_2 - a_3)\]

*deformation*  \[= (u_x - v_y) = (a_1 - a_4)\]
Pseudo Perspective

\[ u(x, y) = a_1 + a_2 x + a_3 y + a_4 x^2 + a_5 xy \]
\[ v(x, y) = a_6 + a_7 x + a_8 y + a_9 xy + a_5 y^2 \]

\( a_4 \) = yaw: rotation around y-axis
\( a_5 \) = pitch: rotation around x-axis

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

\[ u(x, y) = a_1 x + a_2 y + b_1 \]
\[ v(x, y) = a_3 x + a_4 y + b_2 + c x^2 \]

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 expression: facial expression tracking.

Smile Mouth Parameters

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

**Mouth**
- Translation
- Rotation
- Deformation

**Eye**
- Vertical
- Horizontal
- Deformation
Blinking Motion Parameters for Eyes
Rotation

Rotate Face motion parameters

$P_0 \text{ rot } y$

$P_1 \text{ rot } X$
Rotation Motion Parameters

Mid-level predicates for Mouth

Table 1: Mid-level predicates derived from deformation and motion parameter estimations.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Threshold</th>
<th>Derived Predicate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_1$</td>
<td>&gt; 0.25</td>
<td>Mouth rightward</td>
</tr>
<tr>
<td></td>
<td>&lt; -0.25</td>
<td>Mouth leftward</td>
</tr>
<tr>
<td>$x_2$</td>
<td>&gt; 0.1</td>
<td>Mouth upturn</td>
</tr>
<tr>
<td></td>
<td>&lt; -0.1</td>
<td>Mouth downturn</td>
</tr>
<tr>
<td>$x_3$</td>
<td>&gt; 0.02</td>
<td>Mouth expansion</td>
</tr>
<tr>
<td></td>
<td>&lt; -0.02</td>
<td>Mouth contraction</td>
</tr>
<tr>
<td>$T_{xy}$</td>
<td>&gt; 0.005</td>
<td>Mouth horizontal deformation</td>
</tr>
<tr>
<td></td>
<td>&lt; -0.005</td>
<td>Mouth vertical deformation</td>
</tr>
<tr>
<td>$e_{gr}$</td>
<td>&gt; -0.005</td>
<td>Mouth anterior-posterior rotation</td>
</tr>
<tr>
<td></td>
<td>&lt; 0.005</td>
<td>Mouth posterior-anterior rotation</td>
</tr>
<tr>
<td>$v$</td>
<td>&gt; -0.0001</td>
<td>Mouth moving upward/terminal open</td>
</tr>
<tr>
<td></td>
<td>&gt; 0.0001</td>
<td>Mouth moving downward/terminal close</td>
</tr>
</tbody>
</table>
Mid-level predicates for Head

Parameter values used for classifying expressions
Forty Test Subjects

Results

<table>
<thead>
<tr>
<th>Expression</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surprise</td>
<td>91%</td>
</tr>
<tr>
<td>Happiness</td>
<td>95%</td>
</tr>
<tr>
<td>Anger</td>
<td>90%</td>
</tr>
<tr>
<td>Disgust</td>
<td>93%</td>
</tr>
<tr>
<td>Fear</td>
<td>83%</td>
</tr>
<tr>
<td>Sadness</td>
<td>100%</td>
</tr>
</tbody>
</table>
Beginning of Anger Expression
Frames from 10 Video Clips

Results

<table>
<thead>
<tr>
<th>Expression</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surprise</td>
<td>86%</td>
</tr>
<tr>
<td>Happiness</td>
<td>95%</td>
</tr>
<tr>
<td>Anger</td>
<td>80%</td>
</tr>
<tr>
<td>Disgust</td>
<td>50%</td>
</tr>
<tr>
<td>Fear</td>
<td>100%</td>
</tr>
<tr>
<td>Sadness</td>
<td>60%</td>
</tr>
</tbody>
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