Establishing Dense Correspondences between 3D Shapes
Assoc. Prof. Dr.-Ing. Faisal Shafait
Research Highlights

- **Computer Vision**
  - Hyperspectral image analysis
  - 3D deformable modeling
  - Compressive sensing

- **Machine Learning**
  - Meta learning
  - Sparse coding
  - Bayesian dictionary learning

- **Document Image Processing**
  - OCR (Google Books)
  - Information extraction
  - Document forgery detection
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Overview of my Talk
Dense Correspondence on 3D Shapes / Faces

Gilani, Shafait, Mian, CVPR’15
Nose tip detection, pose normalization and cropping
Nose tip detection, pose normalization and cropping
Dense Correspondence on 3D Shapes / Faces

Level set geodesic curves centred at nose tip with speed function $F_1$

\[ \phi_t + F \nabla |\phi| = 0 \]

\[ |\nabla \gamma| F = 1 \]

\[ H = \nabla \frac{\nabla \phi}{|\nabla \phi|} = \left\{ \begin{array}{l} (\phi_{yy} + \phi_{zz})\phi_z^2 + (\phi_{xx} + \phi_{zz})\phi_y^2 + (\phi_{xx} + \phi_{yy})\phi_z^2 \\ -2\phi_y\phi_{xy} - 2\phi_x\phi_{xz} - 2\phi_y\phi_{yz} \\ (\phi_z^2 + \phi_y^2 + \phi_x^2)^{3/2} \end{array} \right\} \]

\[ K = \frac{\phi_x^2(\phi_{yy}\phi_{zz} - \phi_{yz}^2) + \phi_y^2(\phi_{xx}\phi_{zz} - \phi_{xz}^2) + \phi_z^2(\phi_{xx}\phi_{yy} - \phi_{xy}^2)}{(\phi_x^2 + \phi_y^2 + \phi_z^2)^2} + \frac{2(\phi_x\phi_y(\phi_{yy}\phi_{xz} - \phi_{yy}\phi_{yz}) + \phi_y\phi_z(\phi_{xx}\phi_{yz} - \phi_{yz}\phi_{xy}) + \phi_z\phi_x(\phi_{yy}\phi_{xz} - \phi_{yz}\phi_{xy}))}{(\phi_x^2 + \phi_y^2 + \phi_z^2)^2} \]

\[ C = \sqrt{\frac{\kappa_1^2 + \kappa_2^2}{2}} \]

\[ F_1 = \begin{cases} 1 & \text{for } C > (\bar{C} + \sigma_C) \\ 0 & \text{otherwise.} \end{cases} \]
Dense Correspondence on 3D Shapes / Faces

Sampling of first high curvature farthest point and evolving curves from both points.

\[ \phi_t + \mathcal{F} \nabla |\phi| = 0 \]

\[ |\nabla \gamma| \mathcal{F} = 1 \]

\[ H = \nabla, \frac{\nabla \phi}{|\nabla \phi|} = \begin{cases} 
\phi_y + \phi_z \phi_y \phi_z + (\phi_{yy} + \phi_{zz}) \phi_y^2 + (\phi_{yx} + \phi_{yz}) \phi_y \phi_z \\
-2\phi_z \phi_y \phi_{zy} - 2\phi_x \phi_z \phi_{xz} - 2\phi_y \phi_z \phi_{yz} \\
(\phi_y^2 + \phi_z^2 + \phi_{yz}) \end{cases} \]

\[ K = \begin{cases} 
\phi_y^2 (\phi_{yx} - \phi_{zy}) + \phi_z^2 (\phi_{zx} - \phi_{xz}) + \phi_{yz}^2 (\phi_{yy} - \phi_{zy}) + \phi_{yx} \phi_{zy} - \phi_{yz} \phi_{zx} \\
2\phi_y \phi_z (\phi_{yx} \phi_{zy} - \phi_{yz} \phi_{zy}) + \phi_y \phi_z (\phi_{zx} \phi_{xy} - \phi_{yz} \phi_{xz}) \\
+ \phi_x \phi_z (\phi_{xy} \phi_{yz} - \phi_{yx} \phi_{zy}) \\
(\phi_y^2 + \phi_z^2 + \phi_{yz})^2 
\end{cases} \]

\[ C = \sqrt{\kappa_1^2 + \kappa_2^2} \]

\[ \mathcal{F}_1 = \begin{cases} 
1 & \text{for } C > (\bar{C} + \sigma_C) \\
0 & \text{otherwise.} 
\end{cases} \]
Dense Correspondence on 3D Shapes / Faces

\[ \phi_t + \nabla \phi = 0 \]

\[ |\nabla \gamma| \nabla = 1 \]

\[ H = \nabla \cdot \nabla \phi = \frac{\left\{ \phi_{yy} \phi_{zz} + \phi_{zx} \phi_{zy} + \phi_{zy} \phi_{yz} \right\} - 2 \phi_{xy} \phi_{yz} - 2 \phi_{xy} \phi_{zy} - 2 \phi_{xy} \phi_{yz} - 2 \phi_{xy} \phi_{yz}}{(\phi_x^2 + \phi_y^2 + \phi_z^2)^{1/2}} \]

\[ K = \frac{\phi_x^2 (\phi_{yy} \phi_{zz} - \phi_{yz}^2) + \phi_y^2 (\phi_{zx} \phi_{zy} - \phi_{yz}^2) + \phi_z^2 (\phi_{xx} \phi_{yy} - \phi_{xx}^2) + 2 \phi_{xy} \phi_{yz} (\phi_{xx} \phi_{yz} - \phi_{xx} \phi_{yz}) + 2 \phi_{zx} \phi_{zy} (\phi_{xx} \phi_{yz} - \phi_{xx} \phi_{yz}) + \phi_{xz} \phi_{yz} (\phi_{xx} \phi_{yz} - \phi_{xx} \phi_{yz})}{(\phi_x^2 + \phi_y^2 + \phi_z^2)^2} \]

\[ C = \sqrt{\frac{\kappa_1^2 + \kappa_2^2}{2}} \]

\[ F_1 = \begin{cases} 1 & \text{for } C > (\bar{C} + \sigma_C) \\ 0 & \text{otherwise.} \end{cases} \]
Sampling of points with speed function $f_1$
Adaptively sampled points through speed function $F_1$ on 3D faces.
Uniformly sampled points $F_j^2$ through speed function $F_2$ on 3D faces
Dense Correspondence on 3D Shapes / Faces

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Dense Correspondence on 3D Shapes / Faces

Point \( p \)

Surface \( S_s \) of radius \( r_p \)

Points \( F^1 \), on source face

Region \( R \) on target face

Source 3D Face

Target 3D Face

\[
\Delta(s, t) = \frac{\beta_{st} + \beta_{ts}}{2}
\]

\[
\beta(s, t) = x^T \Omega x + y^T \Omega y + z^T \Omega z
\]
Dense Correspondence on 3D Shapes / Faces

Surface matching by minimizing the bending energy between 3D surface patches.

\[
\Delta(s, t) = \frac{\beta_{st} + \beta_{ts}}{2}
\]

\[
\beta(s, t) = x^T \Omega x + y^T \Omega y + z^T \Omega z
\]
Thirty five anthropometric landmarks automatically detected on seven identities of the FRGCv2 database.
85 landmarks detected (red) on neutral and extreme anger expression of a subject from BU3DFE database. The ground truth is represented by blue dots.
Dense Correspondence on 3D Shapes / Faces

Gilani, Shafait, Mian, CVPR’15
Thank You