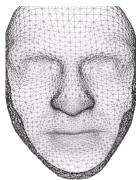


Face recognition using a unified 3D morphable model

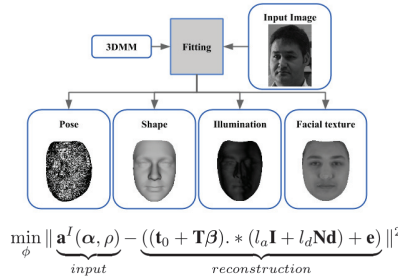
G Hu, F Yan, C Chan, W Deng, W Christmas, J Kittler, N Robertson
 Anyvision, University of Surrey, BUPT, Queen's University Belfast
 huguosheng100@gmail.com

Motivation



$$s = s_0 + S\alpha, \quad t = t_0 + T\beta$$

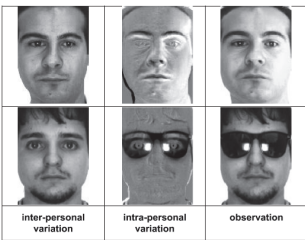
3D morphable model (3DMM)



Problems

- Limited modelling capacity
pose, illumination and expression only
- Fitting difficulties
inaccurate, slow
- Expensive 3D training data

Unified 3D Morphable Model (U-3DMM) Modelling

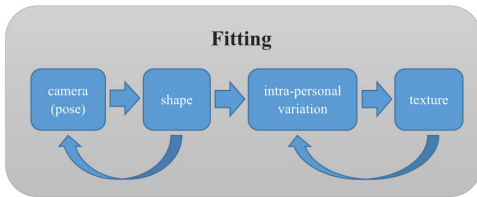


$$a = a^{inter} + a^{intra}$$

$$a^M = \underbrace{t_0 + T\beta}_{inter-personal} + \underbrace{U\gamma}_{intra-personal}$$

Method	Pose	Illumination	Expression	Occlusion	Other
3DSM [6, 3]	✓				
3DMM [7, 8]	✓	✓			
E-3DMM [10, 11]	✓	✓	✓		
U-3DMM	✓	✓	✓	✓	✓

Fitting

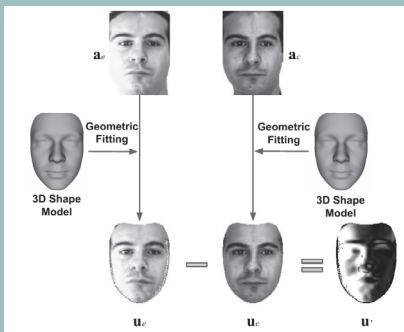


$$\min_{\alpha, \beta, \gamma} \left\| \underbrace{a^I(\alpha, \rho)}_{input} - \underbrace{(t_0 + T\beta + U\gamma)}_{reconstruction} \right\|^2$$

$$\min_{\gamma} \left\| (a^I - t_0 - T\beta) - U\gamma \right\|^2 + \lambda_1 \|(\gamma - \gamma_0) / \sigma_a\|^2$$

$$\min_{\beta} \left\| (a^I - t_0 - U\gamma) - T\beta \right\|^2 + \lambda_2 \|\beta / \sigma_\beta\|^2$$

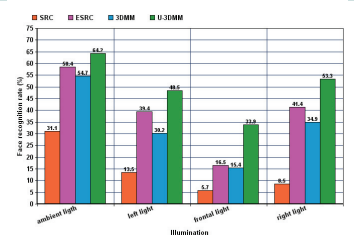
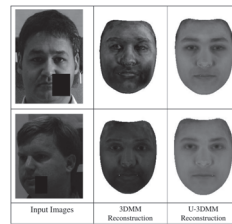
Intra-personal variation data collection



Experiments Settings

Shape and texture parameters are concatenated as face representation. Cosine similarity is used. U-3DMM is compared with Traditional 3DMMs, Extended 3DMM, Sparse Representation Classification (SRC), Extended SRC (ESRC), deep learning methods. We used Multi-PIE, AR, and a synthetic database to evaluate our method.

Pose, occlusion and illumination



Pose and illumination

Table 4: Recognition rate (%) averaging 20 illuminations on Multi-PIE

Method		-45°	-30°	-15°	0°	+15°	+30°	+45°	Avg
Subspace Learning	Li [34]	63.5	69.3	79.7	N/A	75.6	71.6	54.6	69.1
	Deep Learning	RL [2]	66.1	78.9	91.4	94.3	90.0	82.5	62.0
	FIP [2]	63.6	77.5	90.5	94.3	89.8	80.0	59.5	79.3
	MVP [35]	75.2	83.4	93.3	95.7	92.2	83.9	70.6	84.9
3D Method	U-3DMM	73.1	86.9	93.3	99.7	91.3	81.2	69.7	85.0

Other variations

Table 5: Recognition rate (%) evaluated on AR database

Method	Expression	Illumination	Occlusion	Illu.+Occl.	Time
SRC [25]	80.7	71.3	42.5	23.5	-
ESRC [24]	94.3	98.7	80.5	74.5	-
E-3DMM [10]	99.0	-	-	-	slow
3DMM [19]	89.3	99.1	74.5	71.8	23s
U-3DMM	95.3	98.7	92.0	85.5	0.98

¹ The computational complexity of E-3DMM is the same as 3DMM.

Conclusions

- Strong modeling capacity
- Accurate and efficient fitting
- 2D images for training