2D-to-3D

Minh Ngo

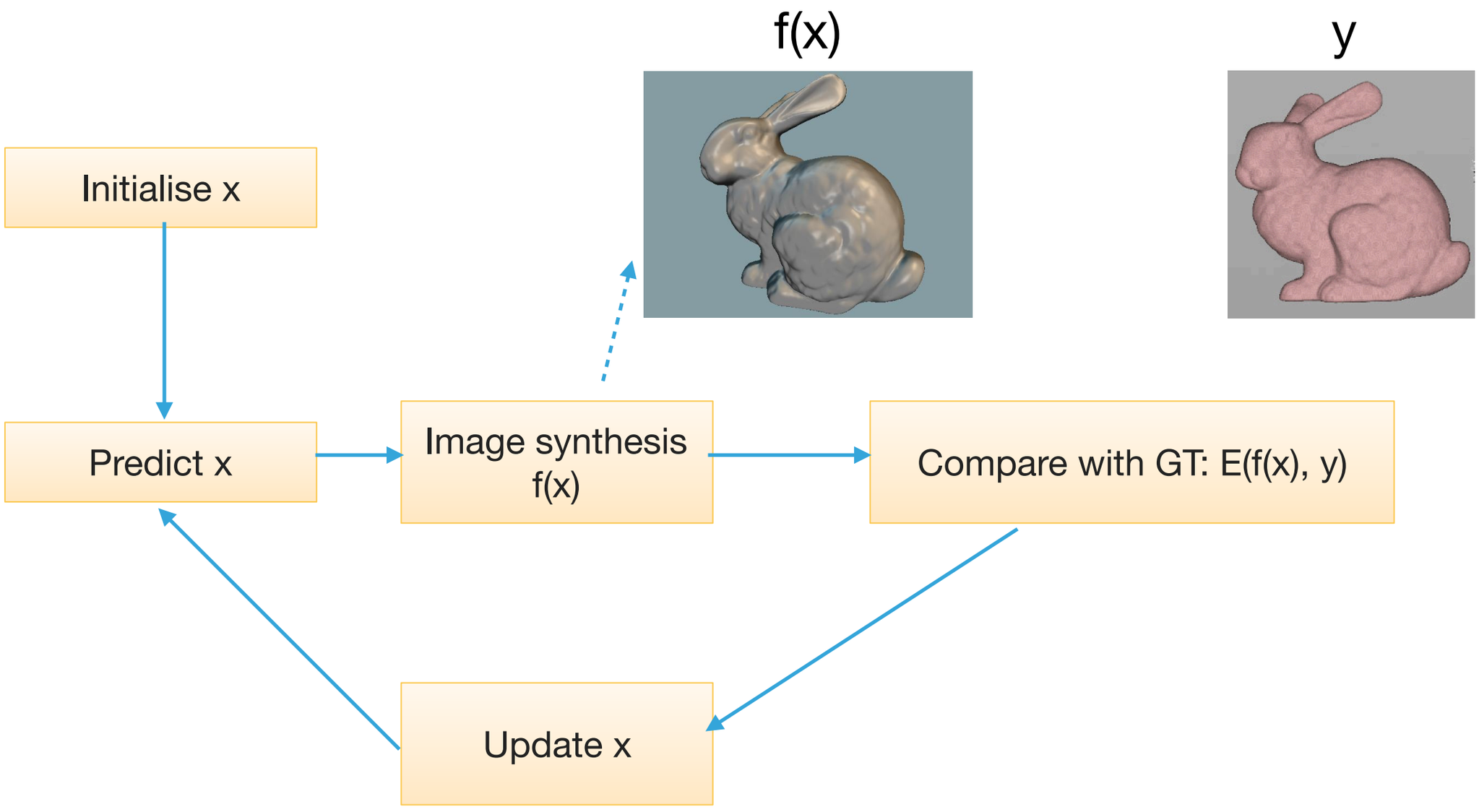
Computer Vision Lab & 3DUniversum

In this assignment

- 2D-to-3D reconstruction

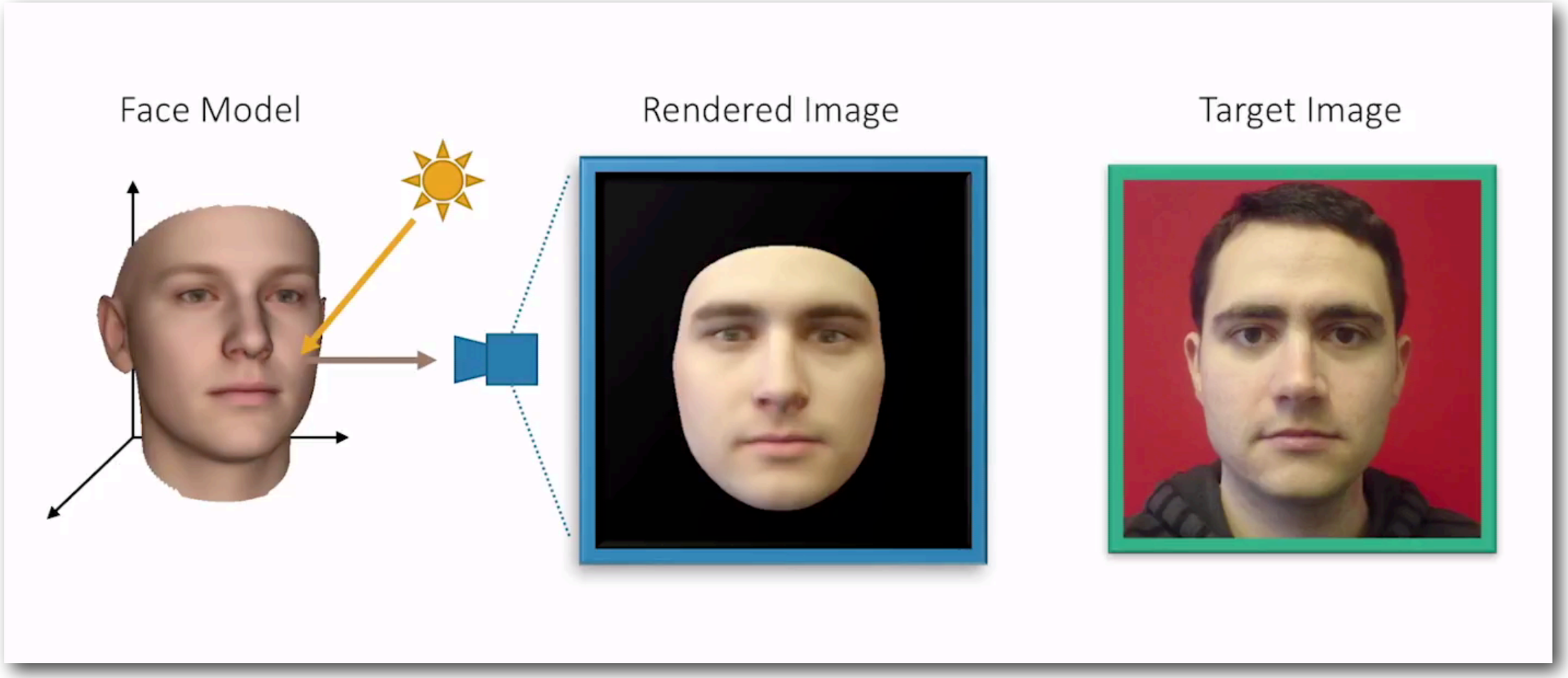
- Avatar expression manipulation

Analysis-by-synthesis



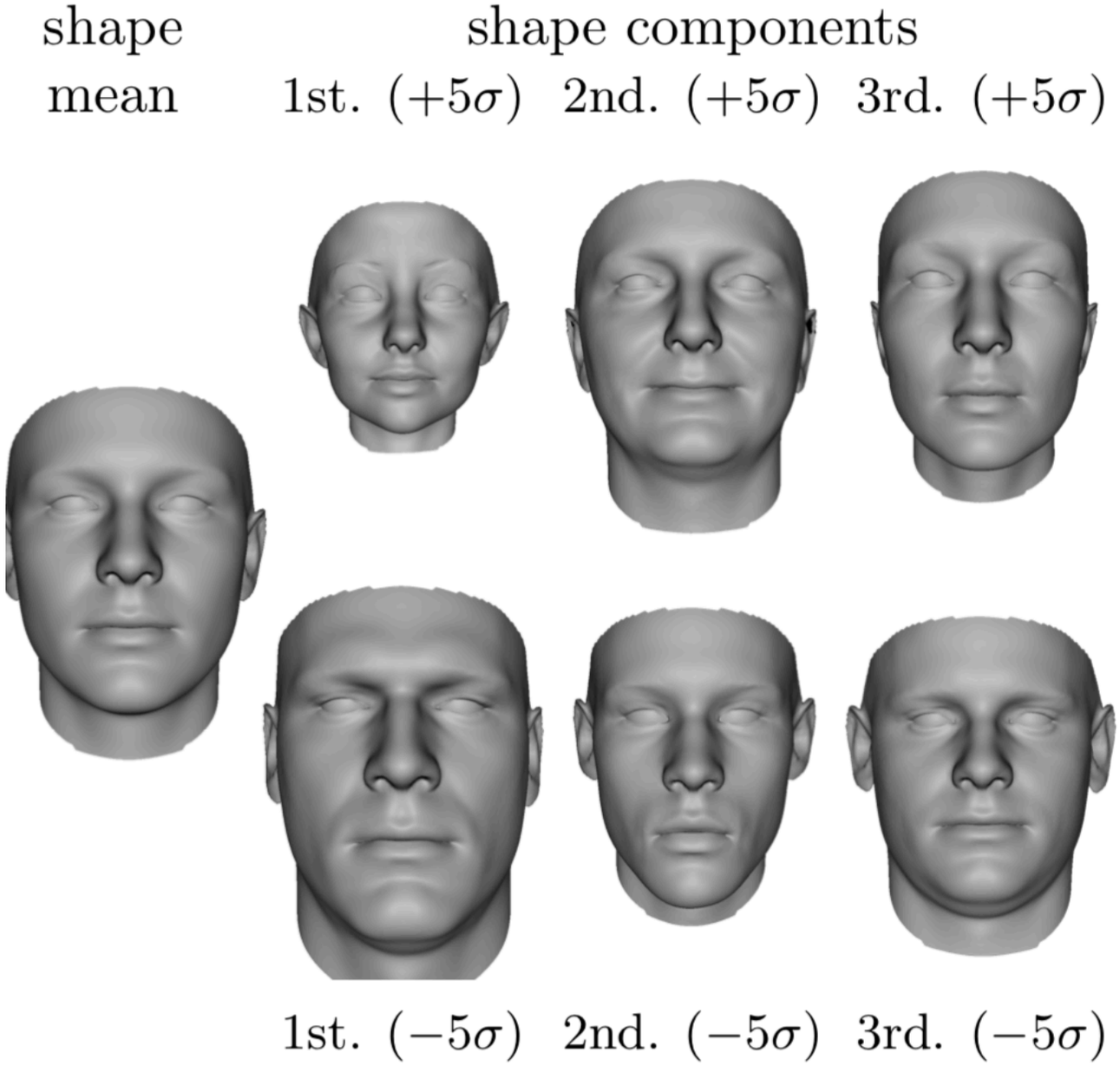
Are $\frac{\partial f(x)}{\partial x}$ **and** $\frac{\partial E(f(x), y)}{\partial f(x)}$ **defined?**

Analysis-by-synthesis



Source: Egger et al (2018)

Morphable Face Model



Shape (identity) modelling

$$G(\alpha) = \mu_{id} + \mathbf{E}_{id}[\alpha \cdot \sigma_{id}]$$

$$x = \{\alpha\}$$

Source: Paysan et al (2009)

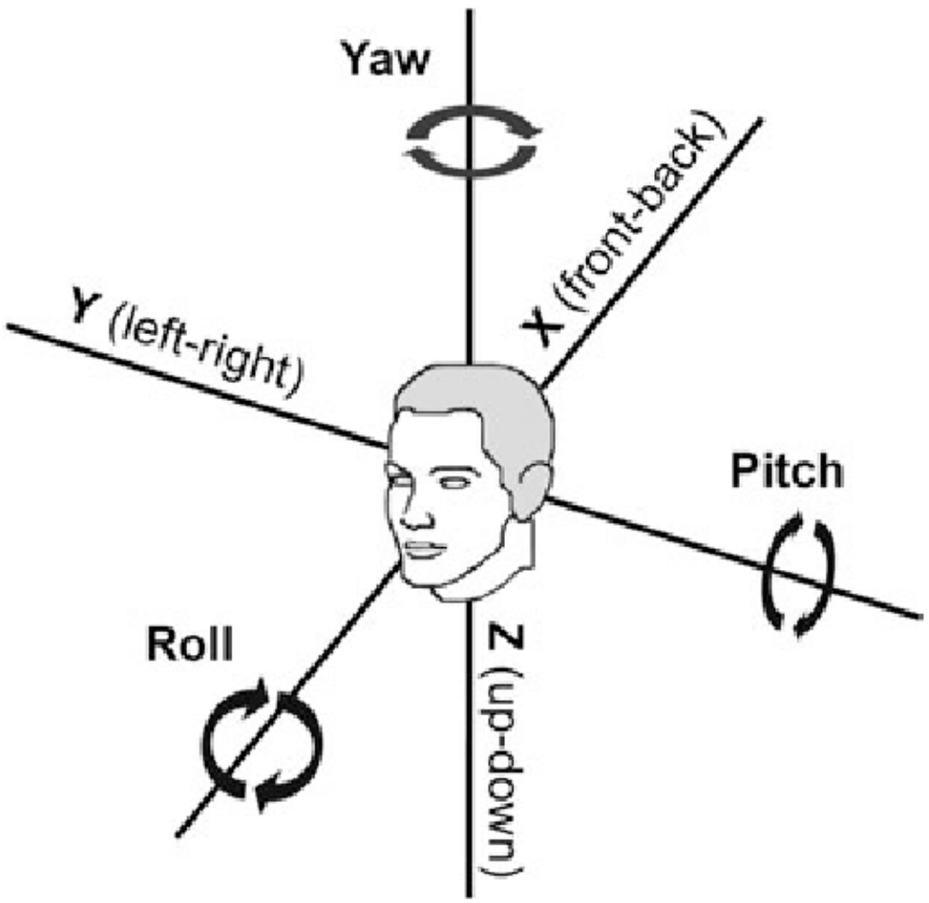
Morphable Face Model

Expression modeling

$$G(\alpha, \delta) = \mu_{id} + \mathbf{E}_{id}[\alpha \cdot \sigma_{id}] + \mu_{exp} + \mathbf{E}_{exp}[\delta \cdot \sigma_{exp}]$$

$$x = \{\alpha, \delta\}$$

Object movement



$$G'(\alpha, \delta, \omega, \mathbf{t}) = \mathbf{R}G(\alpha, \delta) + \mathbf{t}$$

$$\omega = \{\theta_x, \theta_y, \theta_z\}$$

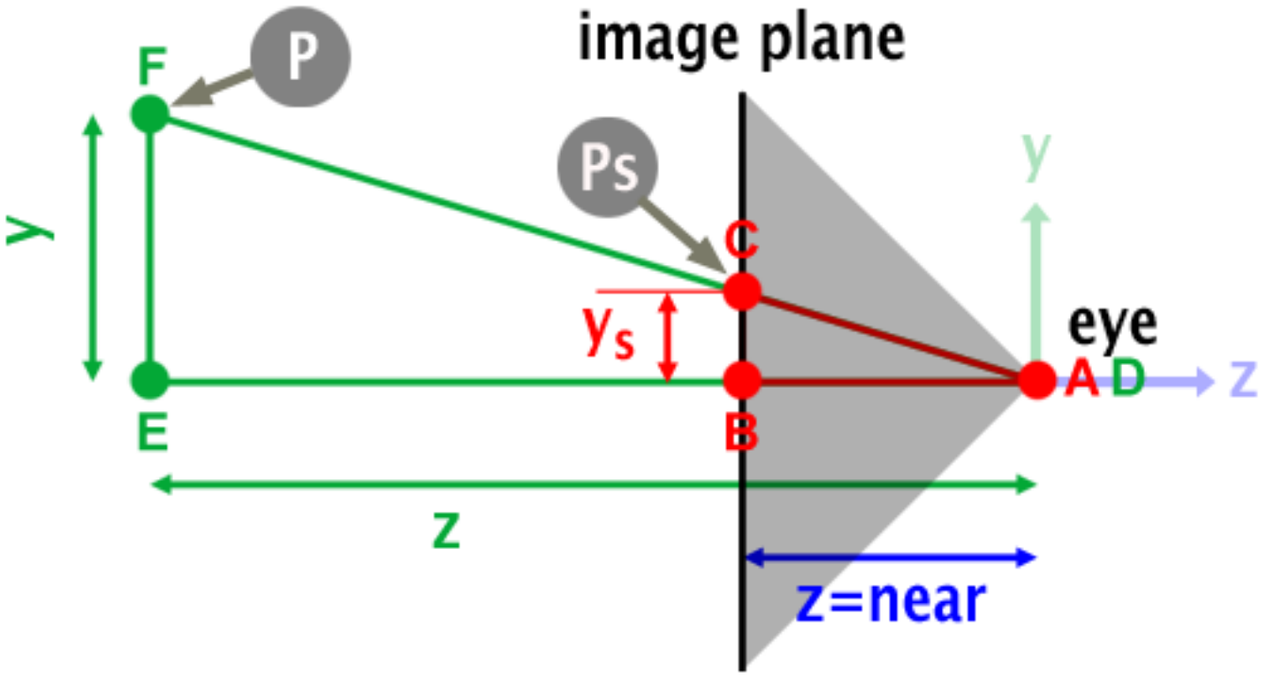
$$\mathbf{R} = \mathbf{R}_z\mathbf{R}_y\mathbf{R}_x$$

$$\mathbf{R_x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta_x) & -\sin(\theta_x) \\ 0 & \sin(\theta_x) & (\cos\theta_x) \end{bmatrix} \quad \mathbf{R_y} = \begin{bmatrix} \cos(\theta_y) & 0 & \sin(\theta_y) \\ 0 & 1 & 0 \\ -\sin(\theta_y) & 0 & (\cos\theta_y) \end{bmatrix}$$

$$\mathbf{R_z} = \begin{bmatrix} \cos(\theta_z) & -\sin(\theta_z) & 0 \\ \sin(\theta_z) & (\cos\theta_z) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$x = \{\alpha, \delta, \omega, \mathbf{t}\}$$

Pinhole camera model



$$\begin{bmatrix} \hat{x} \\ \hat{y} \\ \hat{z} \\ \hat{d} \end{bmatrix} = [\mathbf{V}] \times [\mathbf{P}] \times \begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix}$$

Source: scratchapixel.com

Energy minimization

$$p(\alpha, \delta, \omega, t \,|\, I, F) \sim p(I, F \,|\, \alpha, \delta, \omega, t) \cdot p(\alpha, \delta)$$

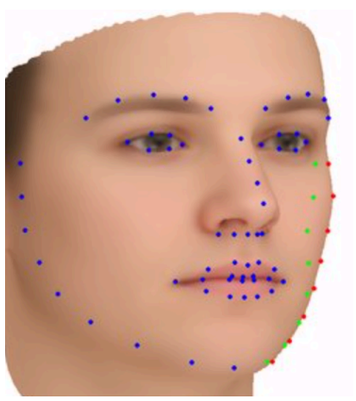
$$E = -\log p(\alpha, \delta, \omega, t \,|\, I, F)$$

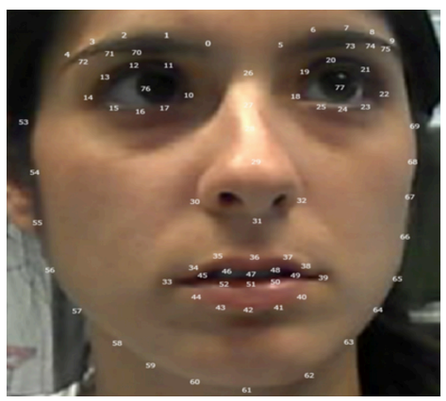
$$E = E_{lan} + \lambda_{alpha} \sum_i \alpha_i^2 + \lambda_{delta} \sum_i \delta_i^2$$

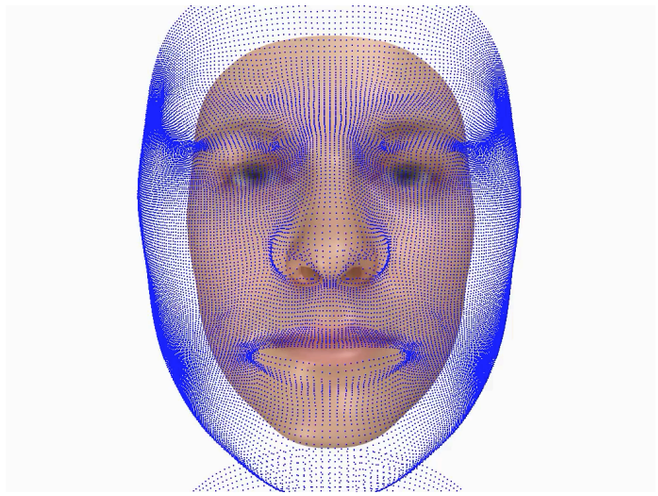
$$minimize_{x=\{\alpha,\delta,\omega,t\}} E(I, F)$$

I - input image
F - landmark ground truth

I,F

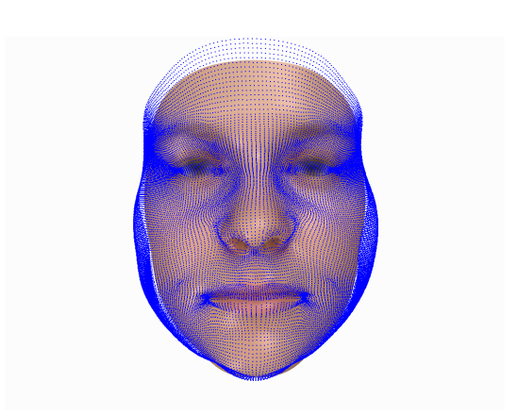






Texturing

∀ projection find a correspondent RGB colour from an image



Source: http://yourface.3duniversum.com/House

Expression manipulation

P1

Frame 1
$\alpha^{(1)}, \delta_1^{(1)}, \omega_1^{(1)}, t_1^{(1)}$

Frame 2
$\alpha^{(1)}, \delta_2^{(1)}, \omega_2^{(1)}, t_2^{(1)}$

Frame 3
$\alpha^{(1)}, \delta_3^{(1)}, \omega_3^{(1)}, t_3^{(1)}$

Frame 4
$\alpha^{(1)}, \delta_4^{(1)}, \omega_4^{(1)}, t_4^{(1)}$

Avatar Frame 1
$\alpha^{(2)}, \delta_1^{(1)},$ **texture**

Avatar Frame 2
$\alpha^{(2)}, \delta_2^{(1)},$ **texture**

Avatar Frame 3
$\alpha^{(2)}, \delta_3^{(1)},$ **texture**

Avatar Frame 4
$\alpha^{(2)}, \delta_4^{(1)},$ **texture**

P2

Frame 1
$\alpha^{(2)}, \delta_1^{(2)}, \omega_1^{(2)}, t_1^{(2)},$ **texture**

questions?