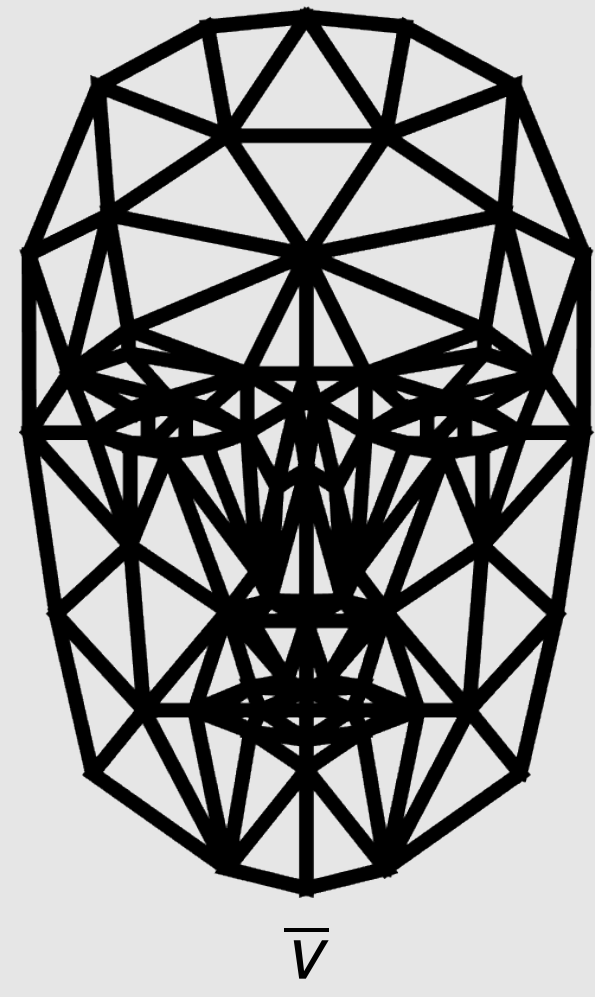
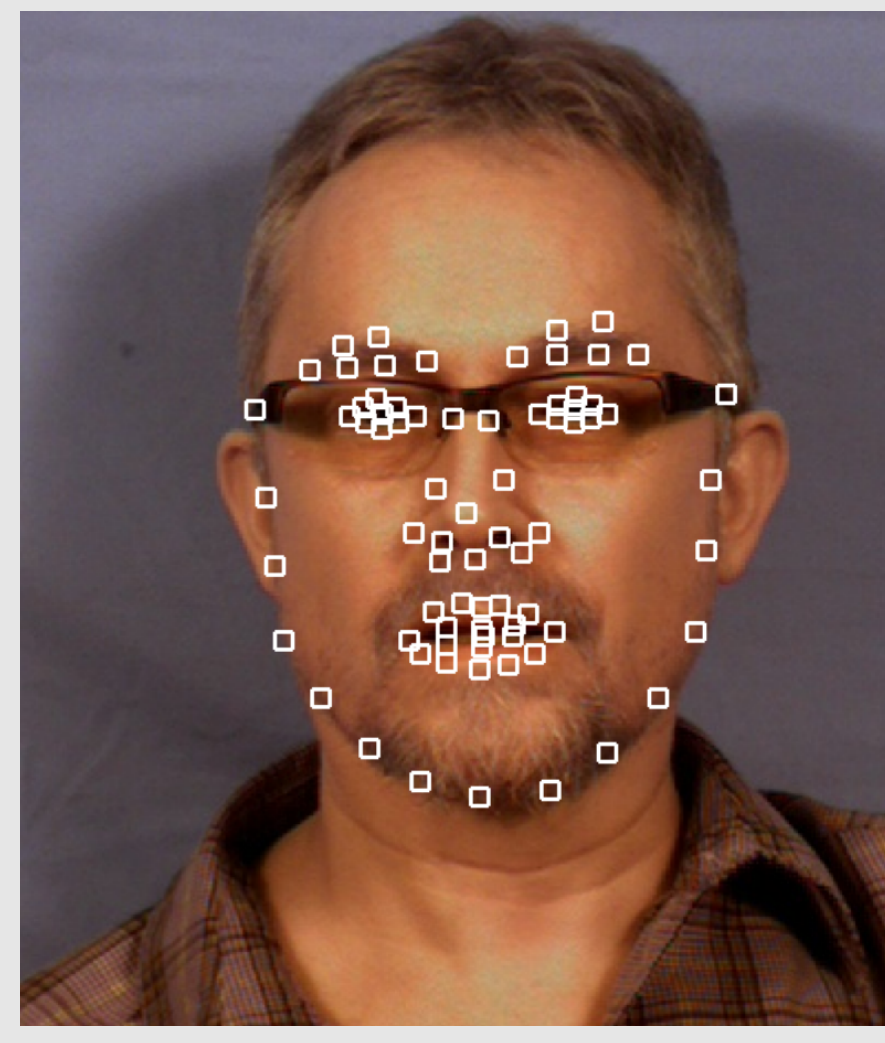


Estimation of Face Parameters using Correlation Analysis and a Topology Preserving Prior

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Estimation of Face Parameters



Candide-3 Face Model

$$\begin{aligned} 3D \quad \hat{v} &= \bar{v} + [S \cdot s + A \cdot a] \\ 2D \quad v' &= M \cdot \hat{v} + t \end{aligned}$$

$$\begin{aligned} \text{Fixed displacement:} \quad S &\in \mathbb{R}^{3N \times 14}, \quad A \in \mathbb{R}^{3N \times 65} \\ \text{Local parameters:} \quad s &\in \mathbb{R}^{14}, \quad a \in \mathbb{R}^{65} \\ \text{Global parameters:} \quad M &\in \mathbb{R}^{2N \times 3N}, \quad t \in \mathbb{R}^{2N} \end{aligned}$$

- ▶ Given facial feature points F
- ▶ Given corresponding model vertices $v_I \subseteq v$ and feature points $f \subseteq F$
- ▶ Estimate global p , shape s and action a parameters of facemodel Candide-3

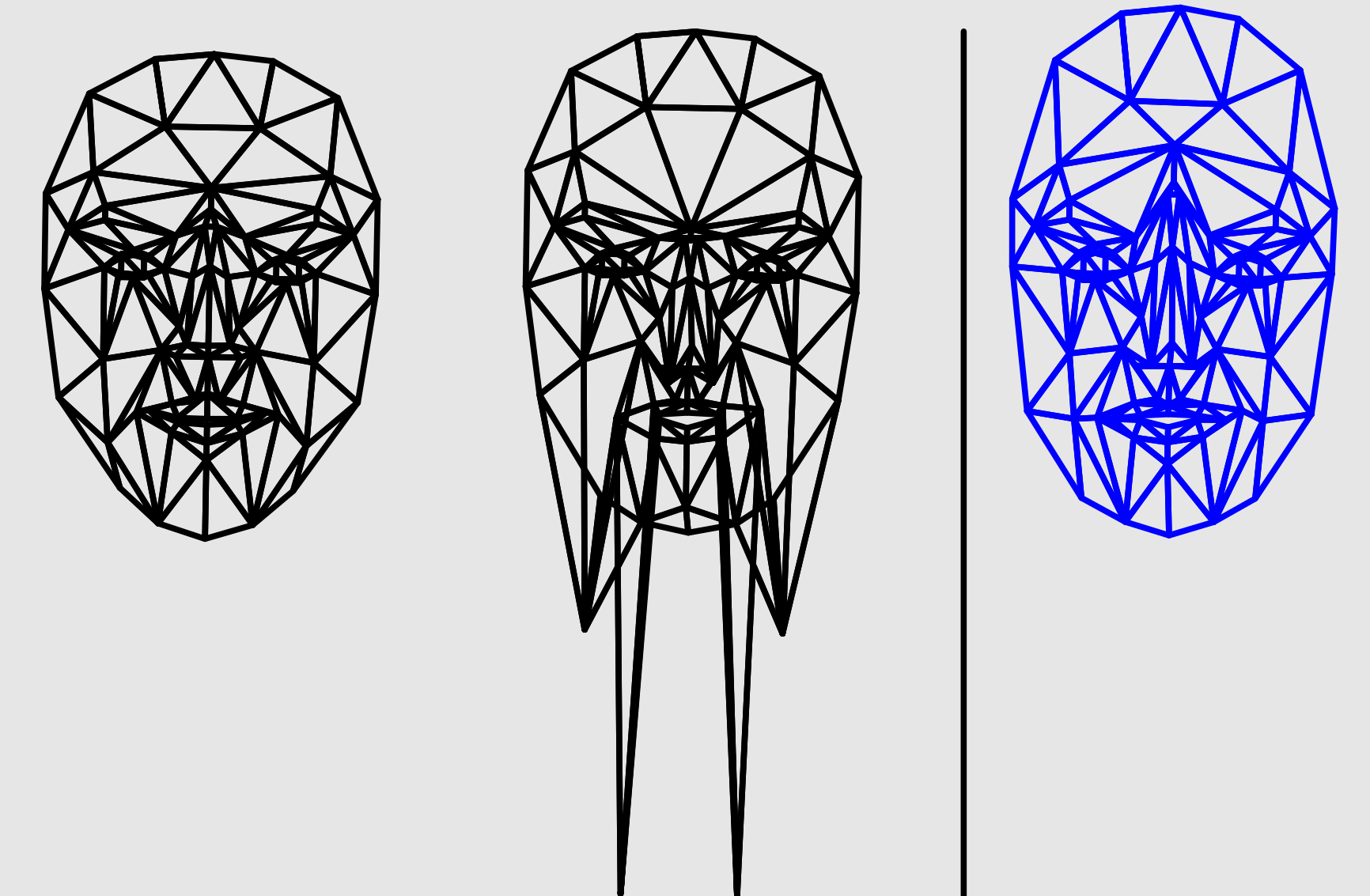
$$\min_{p,s,a} \|v'_I - f\|^2$$

- ▶ 104 vertices \bar{v} , 184 triangles
- ▶ 14 shape parameters s
- ▶ 65 action parameters a
- ▶ MPEG-4 facial animation standard
- ▶ e.g. used in Windows Kinect Face Tracking SDK

Results of Estimation

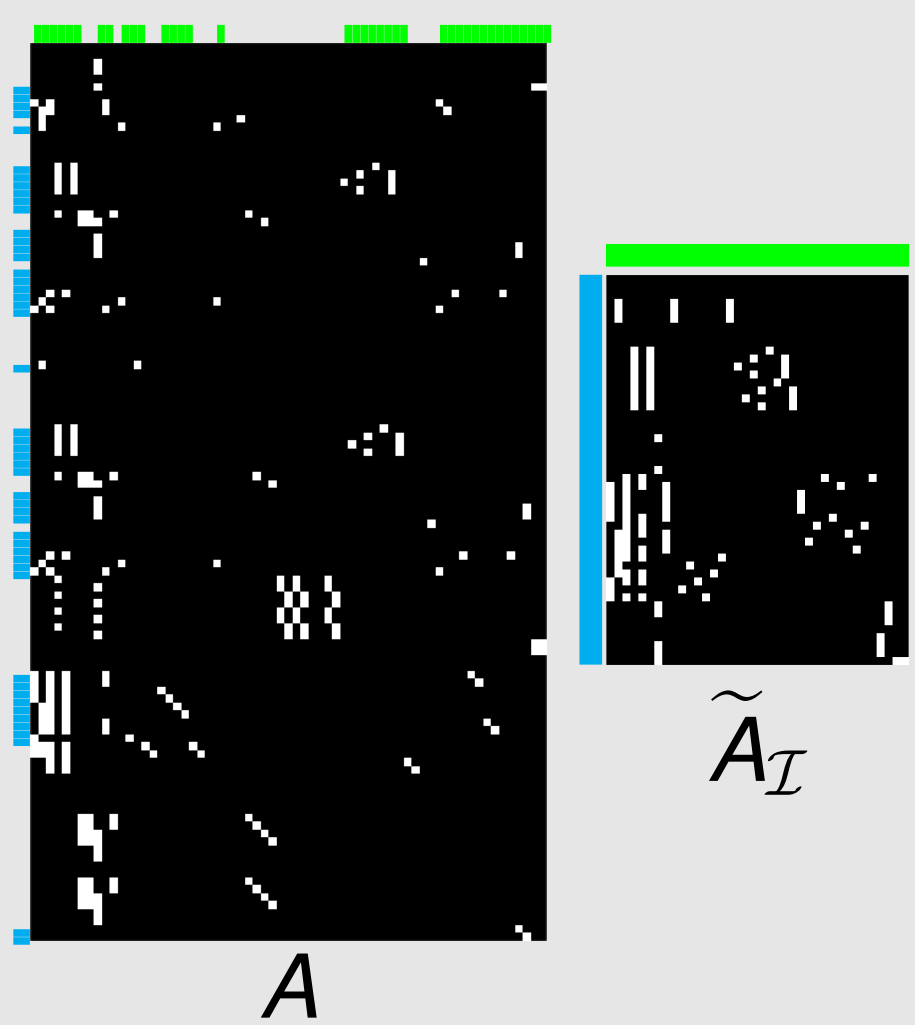
Estimation of action parameters

reference method¹ proposed



- ✗ Weak perspective projection
- ✗ Restriction to 6-9 of 65 action parameters
- ✗ Unnatural mesh configurations

Correlation Based Parameter Sets



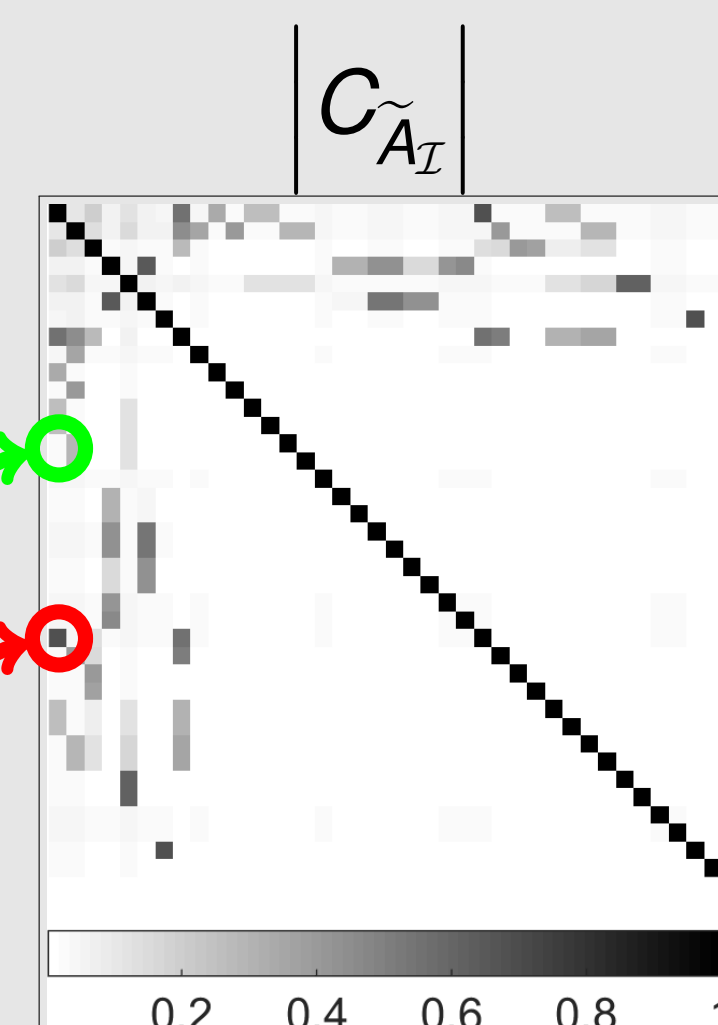
$$A \xrightarrow{\text{delete rows}} A_I \xrightarrow{\text{delete columns}} \tilde{A}_I$$

- ▶ Keep rows of A according to I
- ▶ Keep columns with at least one non-zero entry

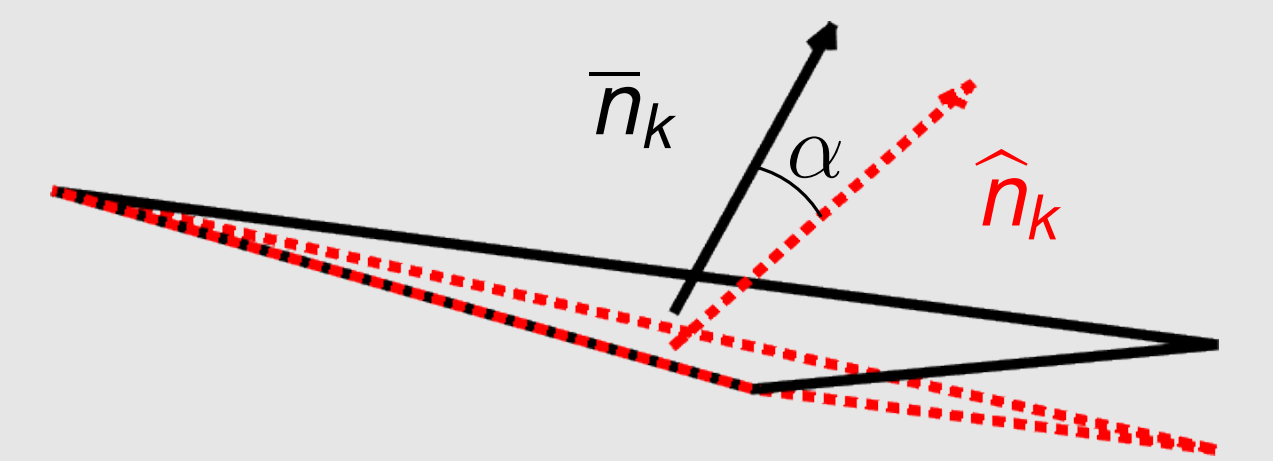
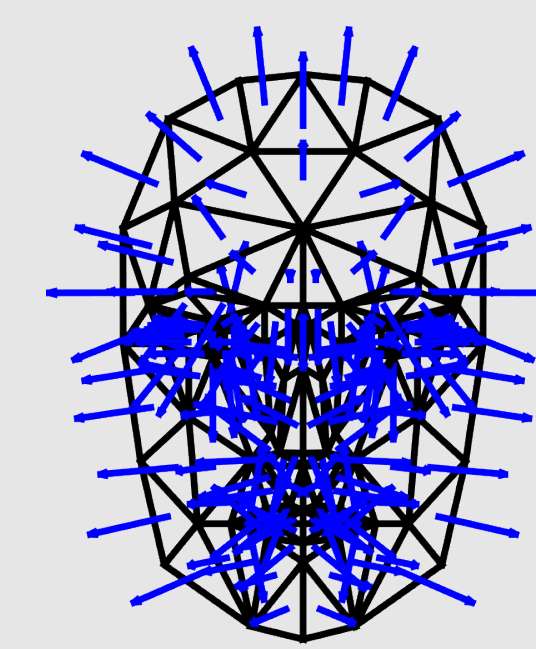
- ▶ Compute correlation matrix $C_{\tilde{A}_I}$ of \tilde{A}_I
- ▶ Define parameter subsets U_k , such that

$$\begin{aligned} \checkmark a_i, a_j \in U_k &\text{ if uncorrelated: } |C_{\tilde{A}_I}(i, j)| < \lambda_c \\ \times a_i, a_j \notin U_k &\text{ if correlated: } |C_{\tilde{A}_I}(i, j)| \geq \lambda_c \end{aligned}$$

for fixed value $\lambda_c \in]0, 1[$, (Procedure analogously for S)



Topology Preserving Prior



- ▶ \bar{n}_k : surface normal of triangle k of standard model \bar{v}
- ▶ \hat{n}_k : surface normal of triangle k of adapted model \hat{v}

$$g(\hat{v}) = \sum_{\forall k} \|\hat{n}_k - \bar{n}_k\|^2 \quad E_{\text{flip}} = \# \{ \alpha \geq 90^\circ \}$$

Results

Proposed Estimation Procedure

$$\min_{p,s,a} \left\{ \|v'_I - f\|^2 + \lambda \cdot g(\hat{v}) \right\}$$

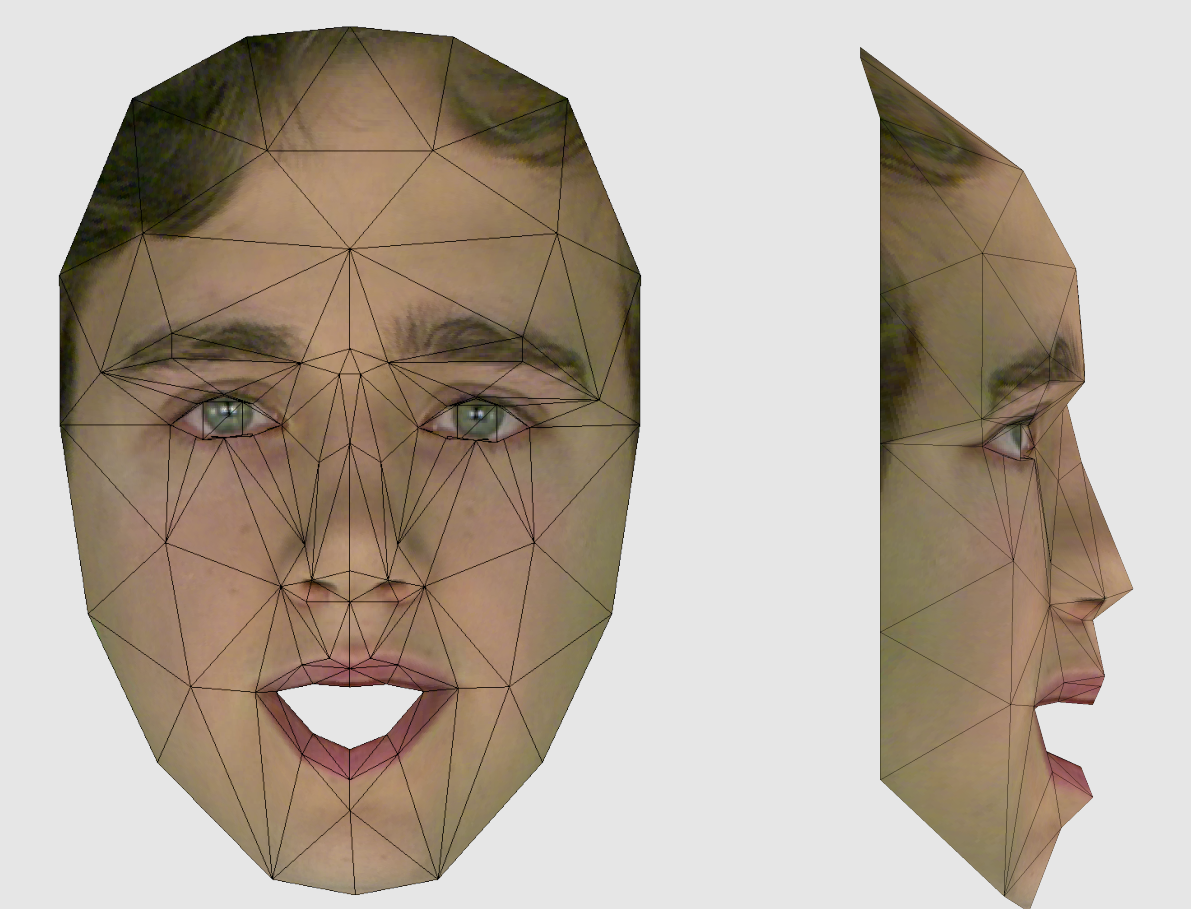
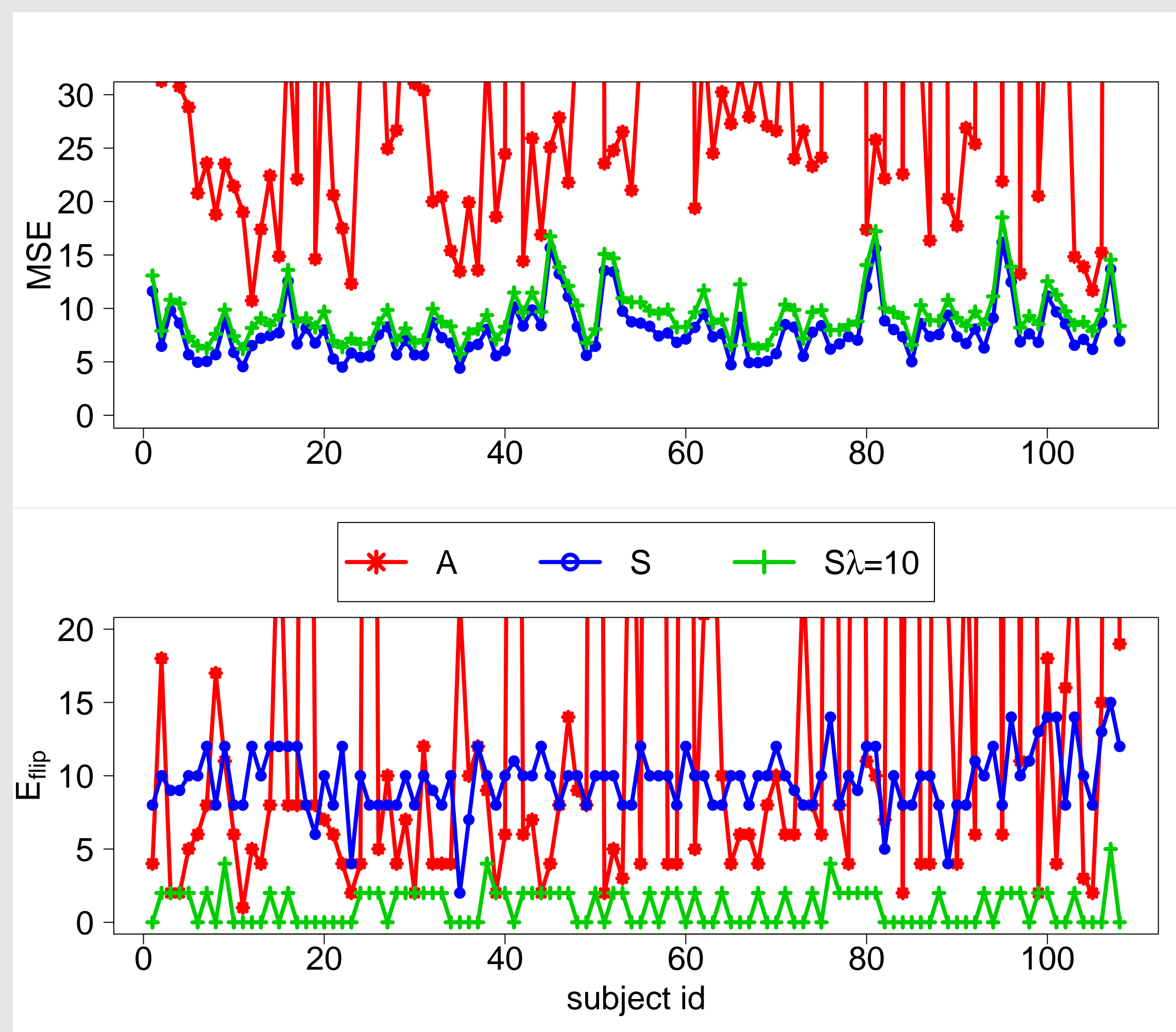
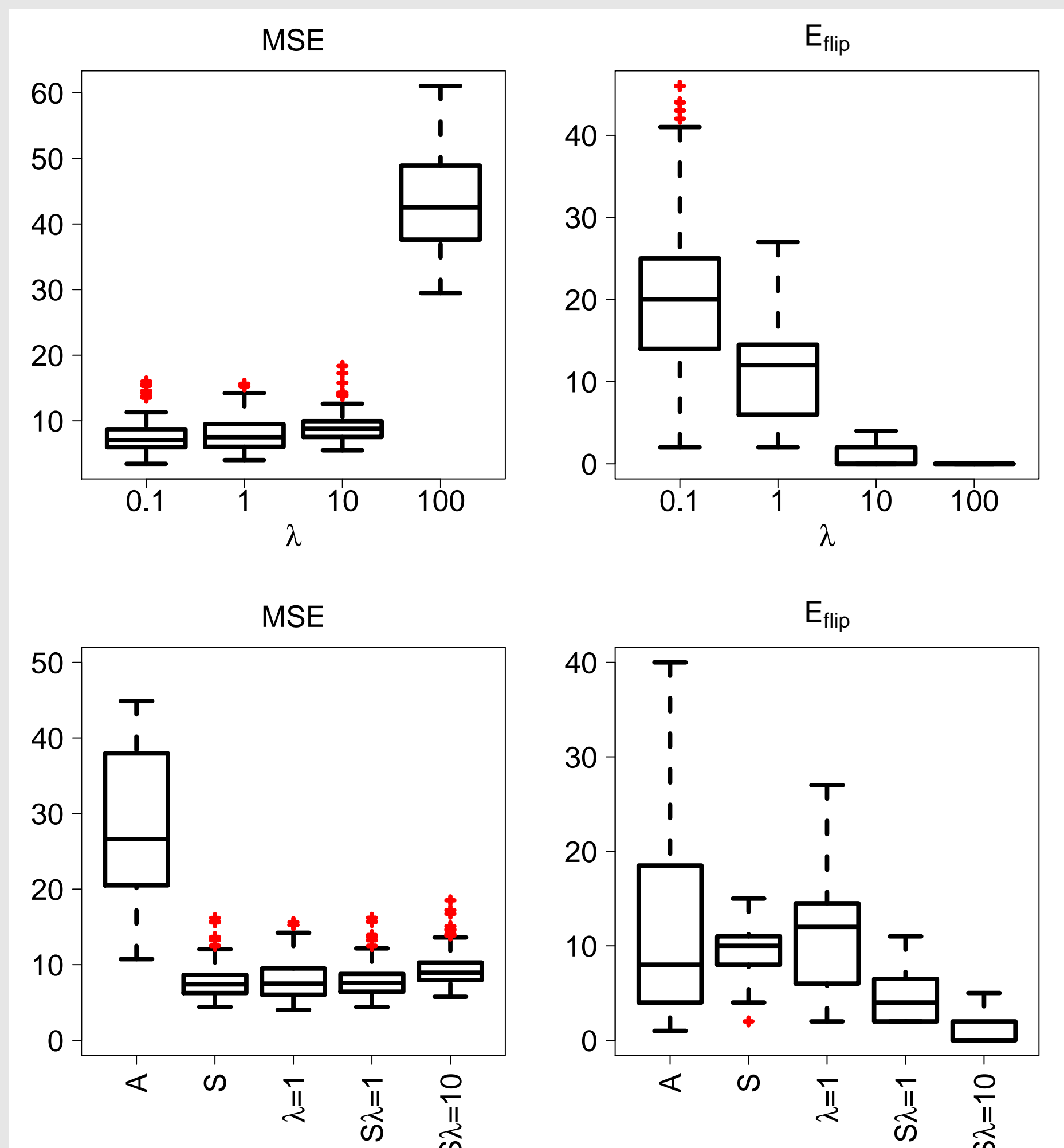
0. Choose values for λ and λ_c
1. For fixed λ_c compute parameter subsets U_k for estimable shape and action parameters
2. Estimate perspective parameters p
3. Estimate shape s and action a parameters of all subsets U_k , separately
4. Repeat steps 2.-3. until convergence

Reference

- ✗ Weak perspective projection
- ✗ 6-9 of 65 action parameters are estimated
- ✗ Unnatural mesh configurations occur for more parameters

Proposed

- ✓ Projective camera model
- ✓ 38 of 65 action parameters are estimated, further increase possible with more facial feature points
- ✓ Unnatural mesh configurations are avoided
- ✓ Reduced average MSE by over 90%



Legend

- “A” reference of Ahlberg
- “S” parameter subsets
- “ $\lambda = 1$ ” topology preserving prior
- “ $S\lambda = 1$ ” parameter subsets and topology preserving prior

[1] Jörn Ahlberg und Robert Forchheimer. “Face tracking for model-based coding and face animation”. In: *Int. J. Imaging Syst. Technol.* 13.1 (2003)