AAM Inference

By fitting an AAM to an unseen image, we produce, hopefully, a compact and powerful descriptor of the shape and appearance of the modelled object that appears in the image.

To do this, a set of parameters must be found that reproduce the image as closely as possible. The most common way to do this is to do this is to minimise the error between the actual and generated image in a least squares sense:

$$\arg\min_{\boldsymbol{p}_a, \boldsymbol{p}_s, \boldsymbol{\Psi}} \left[(\boldsymbol{t} - \text{warp}[\bar{\boldsymbol{a}} + \boldsymbol{\Phi}_a \boldsymbol{p}_a, \bar{\boldsymbol{s}} + \boldsymbol{\Phi}_s \boldsymbol{p}_s, \boldsymbol{\Psi}])(\boldsymbol{t} - \text{warp}[\bar{\boldsymbol{a}} + \boldsymbol{\Phi}_a \boldsymbol{p}_a, \bar{\boldsymbol{s}} + \boldsymbol{\Phi}_s \boldsymbol{p}_s, \boldsymbol{\Psi}])^\mathsf{T} \right]$$

$\boldsymbol{t}$ is the vectorised training image.

There have been many methods proposed to perform this optimisation. The basic method is Gauss-Newton optimisation. This is an iterative gradient descent algorithm, where at each iteration an update is calculated that moves the parameters towards the minimum. However, even with PCA the model parameters have many dimensions, and calculating this update is expensive. Therefore there have been several different methods proposed to speed up the basic algorithm, possible trading update speed for accuracy and convergence speed.

One method, which was the one applied in the original work on AAMs [1], is to learn the relationship between the current parameters and the error from the training examples. This results in quite fast fitting, but suffers fro accuracy issues.

The other method is to improve the speed of analytical update calculation somehow. Popular version of this include the project-out inverse compositional and SIC methods. More recent work as continued to improve on these methods, and the version used to conduct the experiments in this work was the alternating inverse-compositional method proposed in [2].

[1] G. J. Edwards, C. J. Taylor, and T. F. Cootes, "Interpreting face images using active appearance models," in *Proceedings Third IEEE International Conference on Automatic Face and Gesture Recognition*, Apr. 1998, pp. 300–305. doi: 10.1109/AFGR.1998.670965.

[2] G. Tzimiropoulos and M. Pantic, "Optimization Problems for Fast AAM Fitting in-the-Wild," in *2013 IEEE International Conference on Computer Vision*, Sydney, Australia, Dec. 2013, pp. 593–600. doi: 10.1109/ICCV.2013.79.