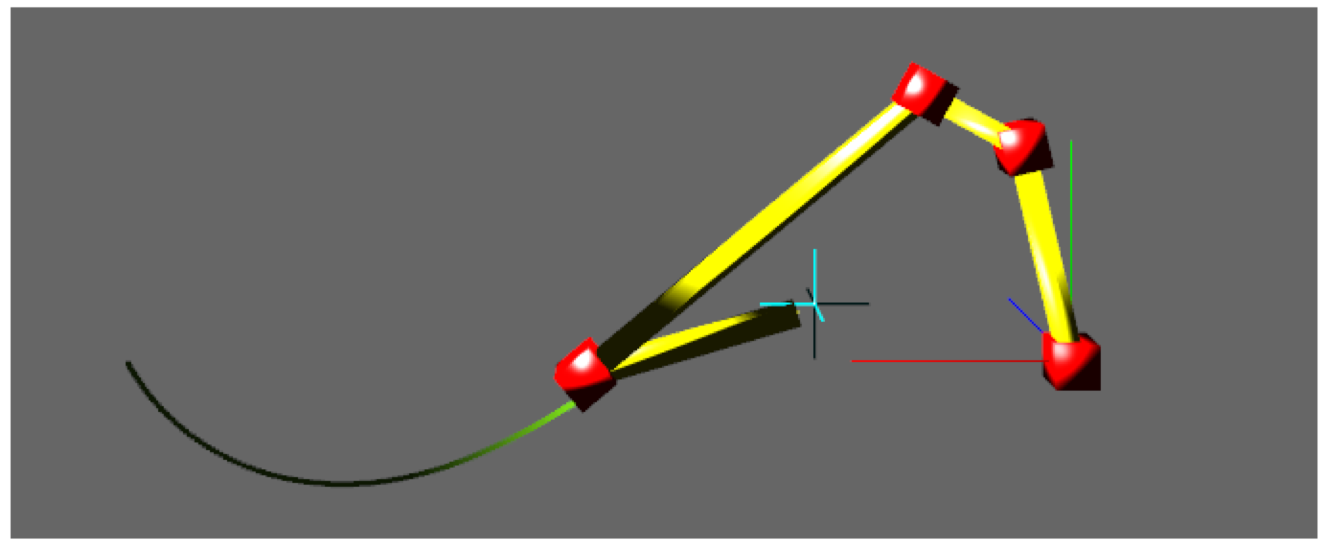
Doctor of Engineering (EngD) in Digital Entertainment, 1st Year

Centre for Digital Entertainment

{ Garoe Dorta Perez, Ieva Kazlauskaite and Richard Shaw } University of Bath

University of Bath

Inverse Kinematics

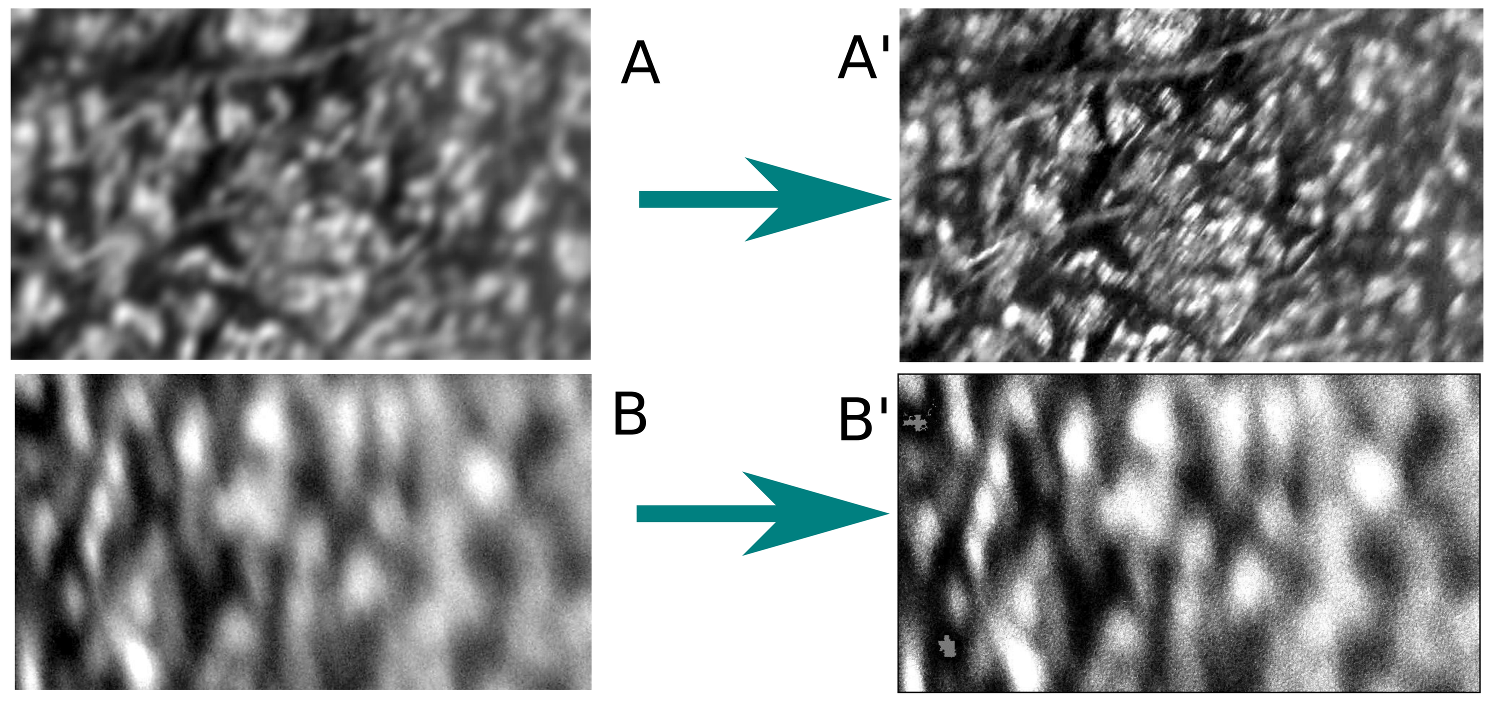


Inverse kinematics uses a known end-effector position $\mathbf{E}$ to calculate the required angles $\boldsymbol{\theta}$ between the parts which ensure that the object reaches the desired target position, such that

$$\mathbf{E} = f(\boldsymbol{\theta}) \rightarrow \boldsymbol{\theta} = f^{-1}(\mathbf{E})$$
$$\partial\mathbf{E} \approx J(\boldsymbol{\theta})\partial\boldsymbol{\theta} \rightarrow \partial\boldsymbol{\theta} \approx J^{-1}(\partial\mathbf{E}),$$

where f is the forward kinematics solver, J is the Jacobian matrix, and $J^{+} = (J^T J)^{-1} J^T$ is the pseudoinverse of J.

Skin Rendering



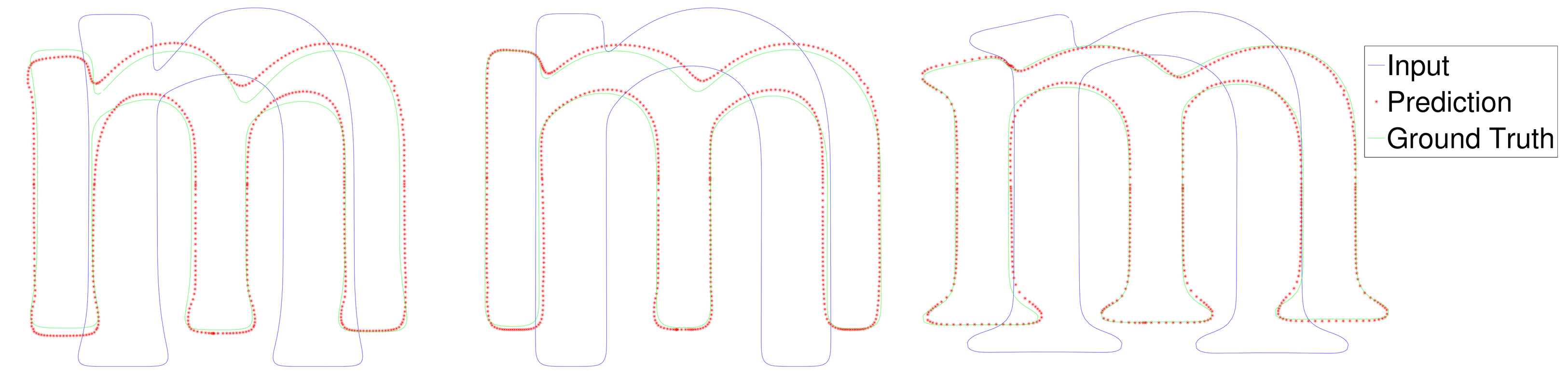
Hertzmann *et al.* [2] introduced a method to apply filters to images based on a best approximate match and a best coherence match pixel search. A high-resolution bump map B' can be synthesized from a lower resolution B and a pair of training samples A and A'.

References

[1] M. Alexa, D. Cohen-Or, and D. Levin. As-rigid-as-possible shape interpolation. In *Proc. of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, SIGGRAPH '00, pages 157–164, NY, USA, 2000.

[2] Aaron Hertzmann, Charles E. Jacobs, Nuria Oliver, Brian Curless, and David H. Salesin. Image analogies. In *Proceedings of the 28th Annual Conference on Computer Graphics and Interactive Techniques*, SIGGRAPH '01, pages 327–340, 2001.

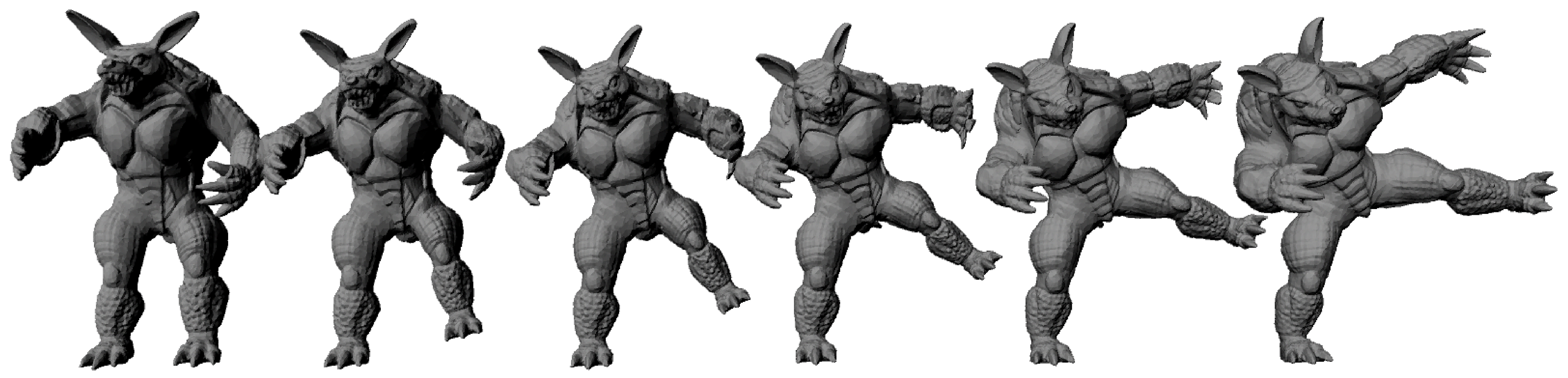
Gaussian Processes



A Gaussian process is a random process, that can be considered as an infinite-dimensional generalisation of the multivariate Gaussian distribution. The main assumption of Gaussian process modelling is that our data can be represented as a sample from a multivariate normal distribution. Each time a Gaussian process is used to model some data, a kernel has to be chosen, and its parameters tuned to maximise the likelihood.

Even with very few training examples, the Gaussian process model gives a reasonable prediction of the shape of a font. The best results were achieved using an exponential kernel with optimised length scale and variance hyperparameters.

Shape Interpolation



Alexa *et al.* [1] introduced a transformation-based interpolation technique that aims to preserve the structure of the parts that are only translated or rotated between the two meshes. For each triangle, the transformation $\mathbf{A}$ is split into rotation and translation/shearing, both of which are interpolated linearly. The corresponding smooth transformation is estimated by minimising the error in Frobenius norm:

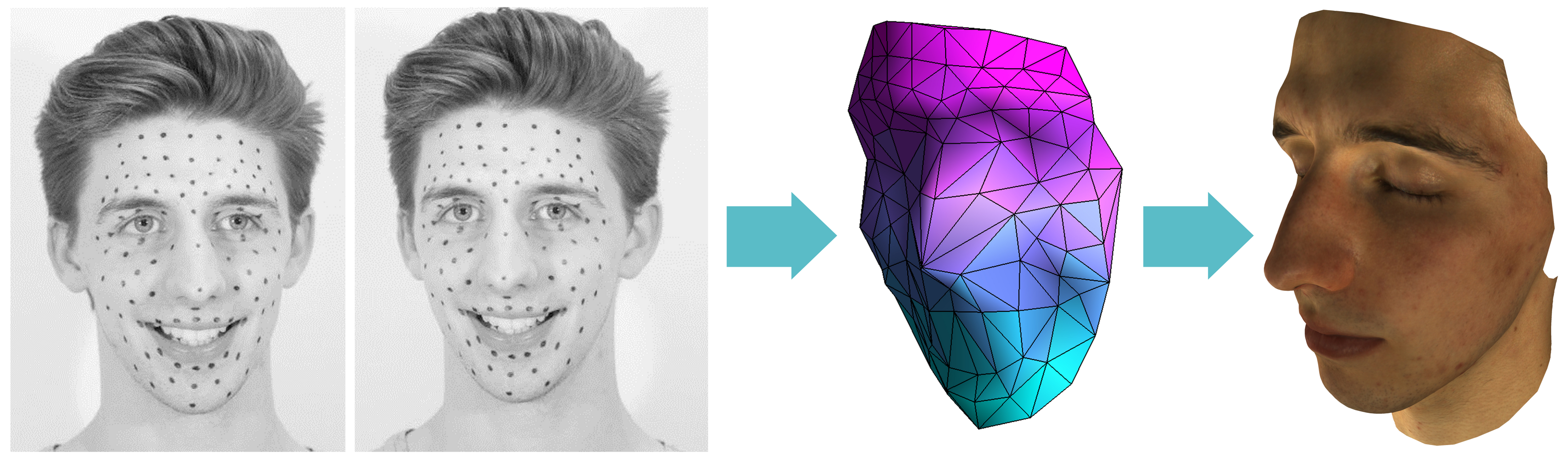
$$E_{V(t)} = \sum_{\Delta \in \mathcal{T}} ||\mathbf{A}_T(t) - \mathbf{B}_T(t)||_F^2,$$

where $V(t)$ are the intermediate positions of vertices, $\mathbf{A}$ is the ideal mapping, and $\mathbf{B}$ is the actual affine transformation.

Future Research

The students undertake an individual three-month summer project in a chosen research area before starting the industrial placement.

Performance-driven Facial Animation



A facial performance is captured using calibrated stereo cameras and tracking markers on the face. The marker positions produce a sparse 3D point cloud, which is in turn used to drive a high-resolution mesh. A new face $\mathbf{x}^*$ can be computed from the 'neutral-face' plus a weighted combination of blend-shape faces $\{\mathbf{x}_i\}_{i=1}^{N}$, where the required weights $\mathbf{w} = \{w_1 ... w_N\}$ are found through an optimisation procedure

$$\mathbf{x}^* = \sum_{i=1}^{N} w_i \mathbf{x}_i \quad \mathbf{w} = \arg\min_{\mathbf{w}} ||\mathbf{x}^* - \sum_{i=1}^{N} w_i \mathbf{x}_i||^2$$

A calibration cube is used to calibrate a pair of stereo cameras. The intrinsic matrix $\mathbf{K}$ and external parameters $\mathbf{R}$ and $\mathbf{t}$ can be recovered through decomposition of the projection matrices $\mathbf{P}$, where

$$\mathbf{u} = \mathbf{P}\mathbf{X} = \mathbf{K}[\mathbf{R}|\mathbf{t}]\mathbf{X}$$

The fundamental matrix $\mathbf{F}$ encompasses the intrinsic geometry between two views of a scene and defines the epipolar constraint

$$\mathbf{u}'^T \mathbf{F} \mathbf{u} = 0$$

We can compute epipolar lines in both views, and points which lie on epipolar lines are constrained to intersect at a point in 3D space.

Contact Information

Web http://www.digital-entertainment.org
Garoe Dorta Perez g.dorta.perez@bath.ac.uk
Ieva Kazlauskaite ik359@bath.ac.uk
Richard Shaw richard.o.shaw@gmail.com