Centre for Digital Entertainment

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

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Inverse Kinematics

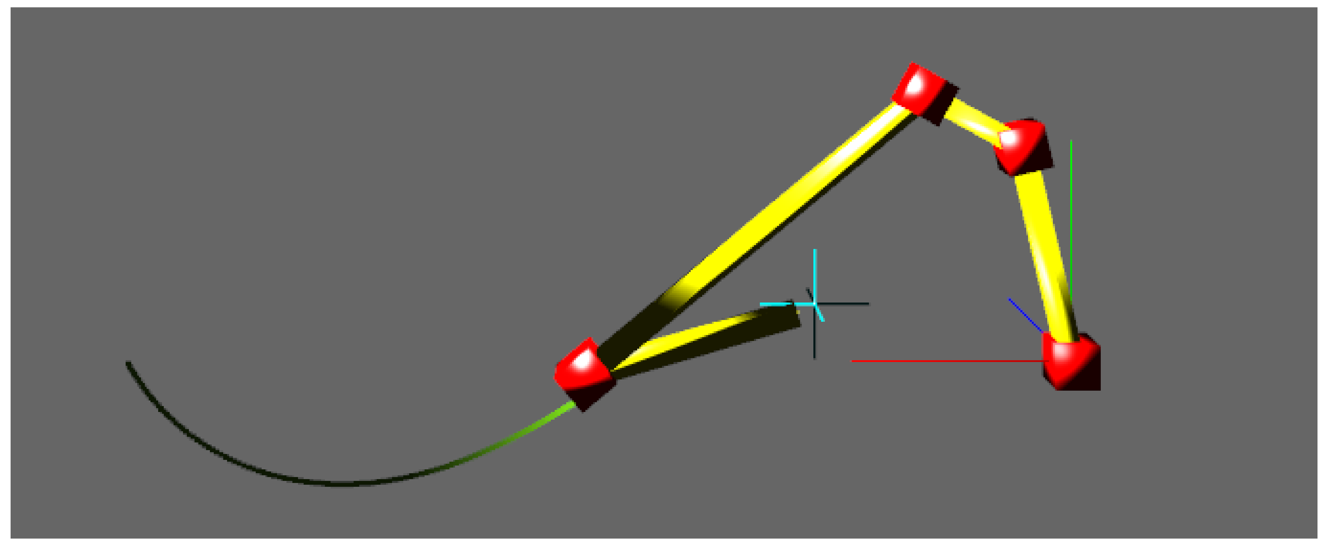


Figure 1: Interactive 3D linkage simulation with end-effector trace.

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

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

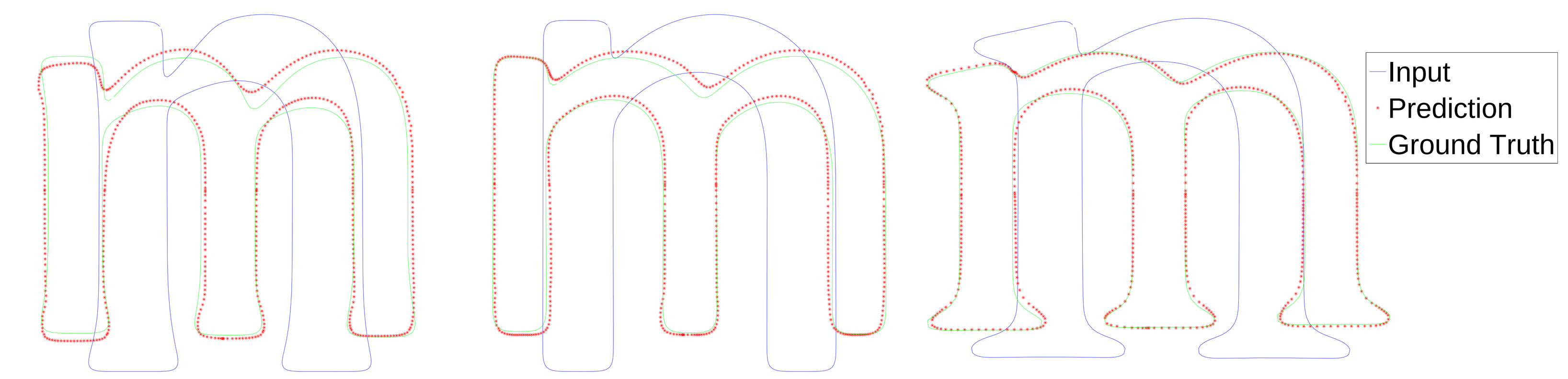
where f is the forward kinematics solver, J is the Jacobian matrix, and $J^{+} = (J^T J)^{-1} J^T$ is the pseudoinverse of J.

3D Reconstruction

References

[1] Marc Alexa, Daniel Cohen-Or, and David Levin. As-rigid-as-possible shape interpolation. In *Proceedings of the 27th Annual Conference on Computer Graphics and Interactive Techniques*, SIGGRAPH '00, pages 157–164, New York, NY, USA, 2000. ACM Press/Addison-Wesley Publishing Co.

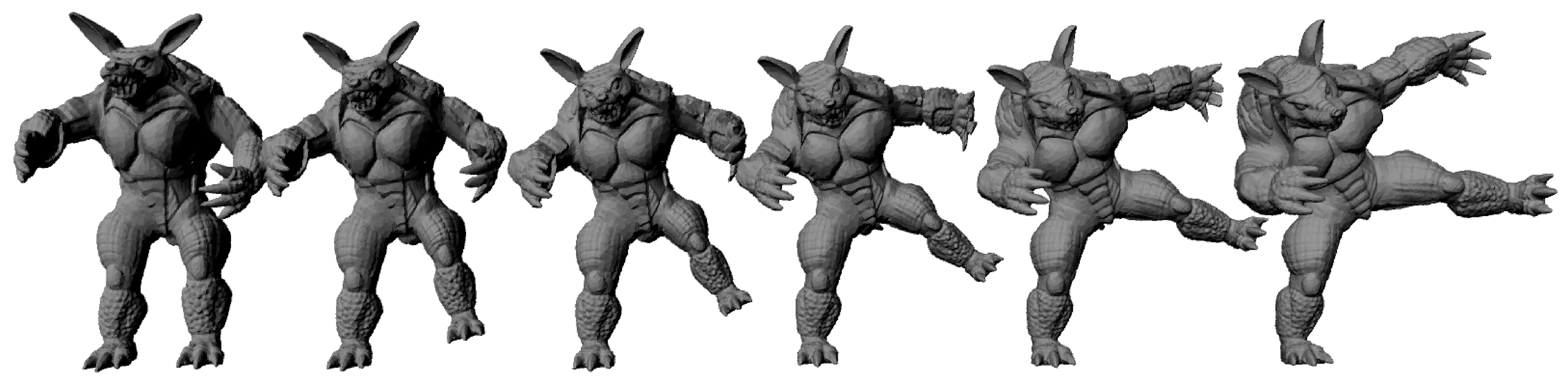
Gaussian Processes



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 the 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 an optimised length scale and variance.

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 estimates 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

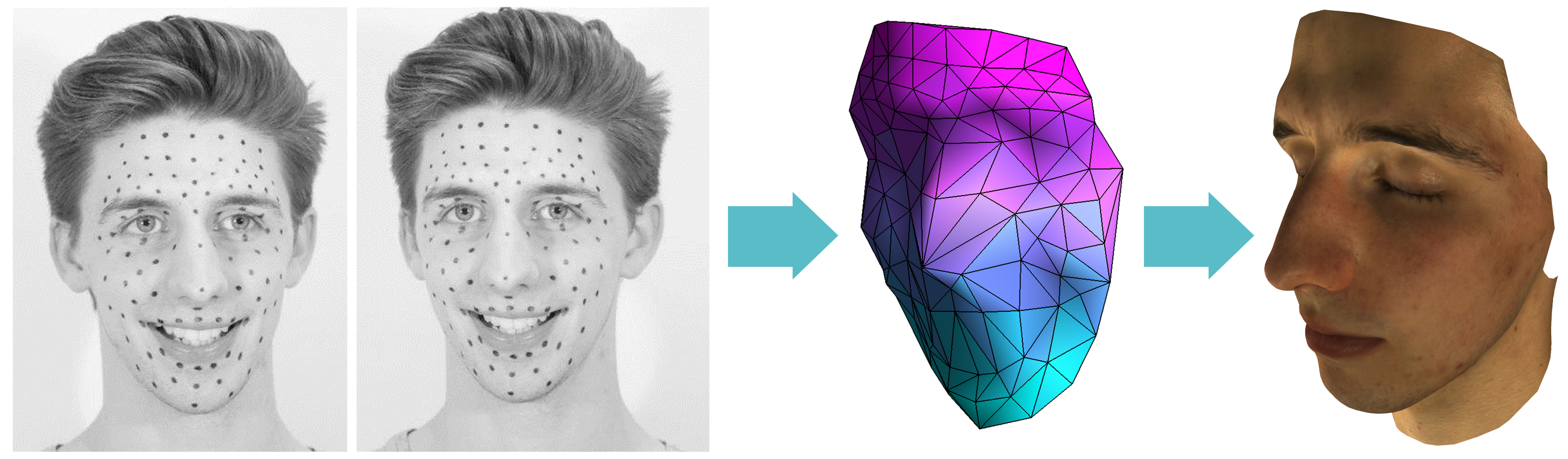
The students undertake an individual three-month summer project in a chosen research area before starting the industrial placement.

SIFT Features

Being able to detect features in an image that are invariant to scale, rotation, translation and changes in illumination has several applications. SIFT features achieves the scale invariance through extrema detection in a difference of Gaussians pyramid built with the image, while the rotation dealt with an orientation assignment based on local image properties.

Performance-driven Facial Animation

Figure 2: Facial performance capture setup.



A facial performance was captured using calibrated stereo cameras and by 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-shapes, where the required weights are found through optimisation

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

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