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1) Why is the frame rate for film different from the rate at which it's projected?

Film runs at 24fps, which is enough to convince viewers of smooth motion: faster would be an unnecessary expense. However, flashing frames with a projector at 24fps is too slow for flicker fusion, especially in peripheral vision, so it is projected at 48fps (each frame shown twice) to avoid apparent flicker.

2) Why is it difficult to convincingly integrate stop-motion animation into real footage?

In stop-motion every frame is a separate photograph of a still scene, and thus doesn't show motion blur. Real footage of moving scenes has motion blur: this is very apparent when combining the two.

3) Write down the lerp at time t between control points $(2, f_0)$ and $(10, f_1)$.

$$f(t) = \left(\frac{10-t}{8}\right) f_0 + \left(\frac{t-2}{8}\right) f_1$$

4) Write down a formula for the i'th Bernstein basis polynomial of degree n.

$$B_{i,n}(s) = \binom{n}{i} (1-s)^{n-i} s^i$$

5) Why does a Forward Kinematic skeleton have to be structured as a tree (or forest) instead of a more general directed graph?

Every node's frame must be related by a joint transformation to the frame of a ***unique parent*** *node (or directly to the world space, with no parent): if there was more than one parent, the two joints could be in conflict leading to an unacceptable ambiguity. This is equivalent to requiring the graph be a tree or forest.*

6) How could you model the joint connecting an eyeball's frame to the head's frame, and in particular, how many DOFs do you need?

A reasonable model has two rotational DOF: fixing the centre of the eyeball to a constant position within the head and allowing rotation about the x axis (up-down) and y axis (left-right).

7) Give the details on performing linear blend skinning for a mesh vertex i with rest position $\vec{p}_{ik}$ with respect to bone k, blend weight w_{ik} for bone k, and transformation $T^{W\leftarrow k}$ from bone k to world space, for $k = 1, \ldots n$.

Each bone provides a guess on where it thinks the vertex should be based on its own frame: $T^{W\leftarrow k}\vec{p}_{ik}$. The actual position of the vertex is a weighted average of the bones' guesses using the blend weights:

$$\vec{p}_{iW} = \sum_{k=1}^{n} w_{ik} \left[T^{W\leftarrow k}\vec{p}_{ik}\right]$$

8) Suggest a context where blend shapes would be more useful than linear blend skinning.

Facial expressions. The face has almost no natural bones, no natural hierarchy, and instead is a complex web of interconnecting muscles attached to the skull, each other, and the skin — so FK and linear blend skinning is a bad fit. Blend shapes are much more intuitive for the artist.

9) Define and describe how matchmove and inverse kinematics are related.

Matchmove: solving for the transformation between world space and camera space given constraints on where markers have to lie.

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Inverse Kinematics: solving for the transformations between bones in a skeleton given constraints on where end-effectors have to lie.

Both are inverse problems, solving for transformations given geometric constraints on the transformations, and may use the same optimization methods.

10) Why is the problem $\min_{x,y}(x-y-1)^2$ (solve for x and y) ill-posed, and how could you make it well-posed?

There are infinitely many solutions: any pair (x, y) where $x = y + 1$ achieves the minimum value of 0. A well-posed problem must have a unique solution instead. This could be ***regularized*** *to make it well-posed, for example adding a term that penalizes larger solutions:*

$$\min_{x,y}(x-y-1)^2 + 10^{-6}(x^2+y^2)$$

This has the unique solution $x = 1/(2+10^{-6}), y = -1/(2+10^{-6})$.