Method S1. Systematically Sampling Joint Poses in Maya

To build a simple forward kinematic model in Maya 2016 (Autodesk, San Rafael, CA, USA), begin with the reference pose for your individual, which should include anatomical coordinate systems that are parent constrained to bone mesh models. Create a character animation joint named "myJoint." Point and orient constrain myJoint to the proximal anatomical coordinate system for the biological joint you are modeling (e.g., proximal right hip anatomical coordinate system). Then, parent constrain the distal element's mesh model (e.g., right femur) to myJoint.

Now, if rotations and/or translations are applied to myJoint, the anatomical joint will follow. The following MEL code can be run in the Script Editor to systematically apply rotations to myJoint:

```
{
int $i;
int $j;
int $k;

int $frame = 1;
currentTime -edit 1;

for ($i = -180; $i < 181; $i = $i + 5) //increment FE from -180° to 180° at 5-degree intervals
        {
        for ($j = -90; $j < 91; $j = $j + 5) //increment ABAD from -90° to 90° at 5-degree intervals
                {
                for ($k = -180; $k < 181; $k = $k + 5) //increment LAR from -180° to 180° at 5-degree intervals
                        {
                        setKeyframe -at rotateZ -v $i -t $frame myJoint; //set FE
                        setKeyframe -at rotateY -v $j -t $frame myJoint; //set ABAD
                        setKeyframe -at rotateX -v $k -t $frame myJoint; //set LAR
                        $frame = $frame + 1;
                        }
                }
        }
}
```

The range of excursions in each degree of freedom and the resolution of sampling can be easily modified (see commented lines of code above). If this animation will be used to automatically check for mesh interpenetration, the entire keyset should be baked for myJoint and the proximal and distal elements' mesh models.

ESM for: Manafzadeh AR, Padian K. 2018 ROM mapping of ligamentous constraints on avian hip mobility: implications for extinct ornithodirans. Proceedings of the Royal Society B. (doi:10.1098/rspb.2018.0727)