ECS279 Exercise1 Report

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February 2020

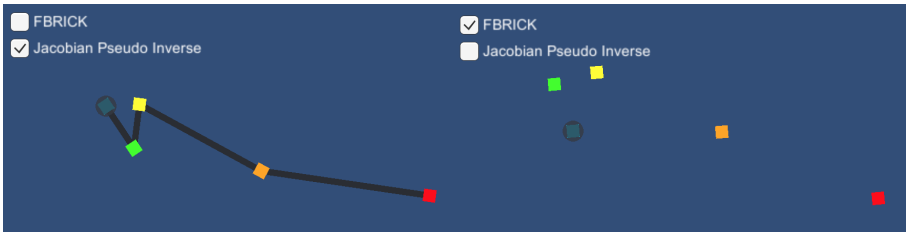

Figure 1: Jacobian Pseudo-inverse

Figure 2: FABRIK

This project implements inverse kinematics by two approaches: FABRIK and Jacobian pseudo-inverse. Choose one method on the top left corner and use mouse to set the target's position. To differentiate two methods, arms are not visible in FABRIK mode. By changing the "stride" value in "IK" Script bounded to Joint 5, you can change the rotation speed for Jacobian pseudo-inverse.

FABRIK implements IK by changing joints' positions while Jacobian pseudo-inverse changes joints' rotations. Since FABRIK is fully explained in Aristidou's paper, here we only focus on Jacobian pseudo-inverse algorithm. Since arms are on a 2D plane, we set target and all joints' z-position to 0. Ratios of arm lengths are set strictly to 13.5:11:3.5:4. Joint 1 is set an initial non-zero rotation value so that matrix inverse operation is workable in later calculation. The algorithm first checks if the target is reachable. If not, we set all joint's rotation value same to that of the target, in which case all joints are in a line and points to the target. Otherwise, we update all joints' rotation values(except the end effector) iteratively until the end effector reaches the target. In each iteration we add a delta orientation(dO) to joint 1 to 4. As explained in Bermudez's blog, $dO = J^+ * (targetPos - endEffectorPos)$. Since we've learned that $J^+ = J^T(JJ^T)^{-1}$ in class, we can make the algorithm works. In order to make JJ^T a full-rank matrix which is invertible, I didn't use z-position value in J, making it a 2*4 matrix. Hence, J^+ is a 4*2 matrix. To make dO a vector of length 4, only x and y of $targetPos - endEffectorPos$ are used in the matrix-vector multiplication.

If a target is not reachable, we can directly set joints in a line, which doesn't need iteration. Otherwise, among two iterative methods, FABRIK is faster than Jacobian pseudo-inverse. Jacobian pseudo-inverse method takes more time for fine-tuning regardless of large changes or small changes. However, Jacobian pseudo-inverse method is more suitable for robotic arms because it rotates joints continuously to the target other than gives the final state.