

FABRIK

- Forward And Backward Reaching Inverse Kinematics (FABRIK) is an iterative approach for solving inverse kinematics (IK) problem
- IK is a method of determining the joint parameters (the Degrees of Freedoms or DoFs) that provide a desired position for each of the end-effectors. One common desired position is to have the end-effectors reach or grab a target.

Previous Approaches

- One method is to model the problem as finding a local minimum of a set of non-linear equations or use algorithms like BFGS to solve an equivalent minimization problem. However, these have very high computational cost
- One popular method is Cyclic Coordinate Descent (CCD) algorithm, where each joint angle is individually varied in each iteration to minimize the objective function. Multiple cycles of such iterations can reach a solution quite fast, but results could be unrealistic postures.
- Other methods too suffer from either of these problems.

Articulated Body model

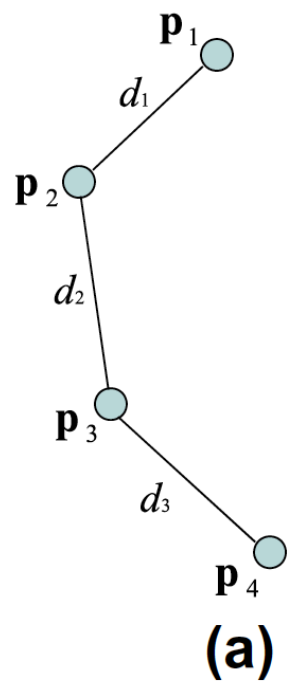
- Links -> rigid body objects
- Joints -> connects the links and permits some relative motion between them
- Chains -> Sequence of links and joints
- End Effectors -> Joints with no children

Algorithm

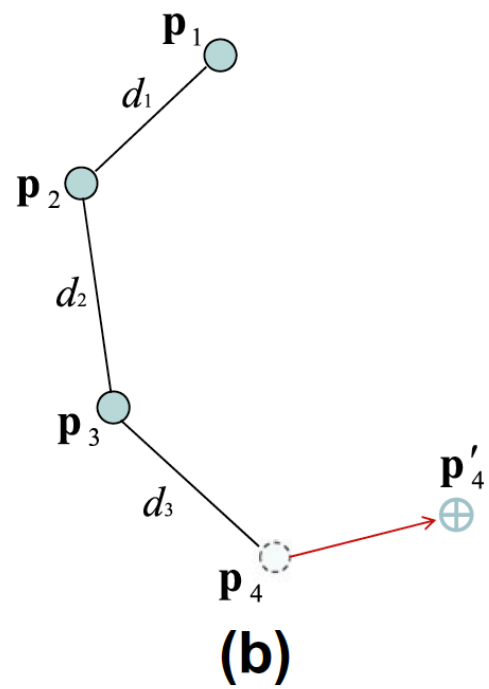
- Given: joint positions p_i for $i = 1$ to n , the target position t and the distances between each joint $d_i = |p_{i+1} - p_i|$ for $i = 1, \dots, n-1$
- if $|p_1 - t| > d_1 + d_2 + \dots + d_{n-1}$ then // target is unreachable
find the vector $(t - p_1)$ and find the relative position of each point along that vector. i.e. imagine stretching out the complete chain in target's direction.
- else // target is reachable
 - Set $b = p_1$ as the initial (root) position
 - Find distance of end-effector from target i.e. $\text{diff} = |p_n - t|$
 - While ($\text{diff} > \text{tolerance}$)
 - Perform forward and backward pass

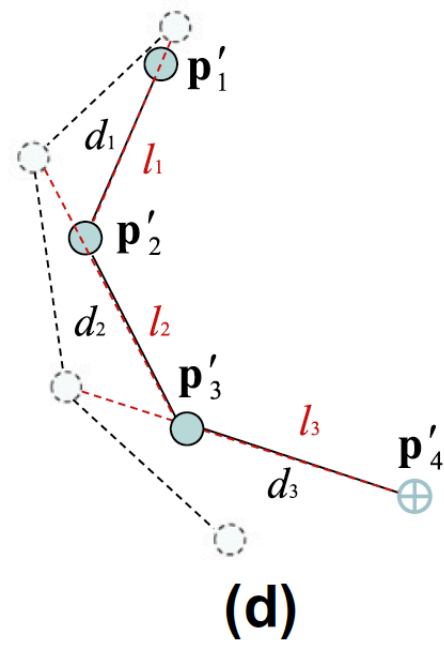
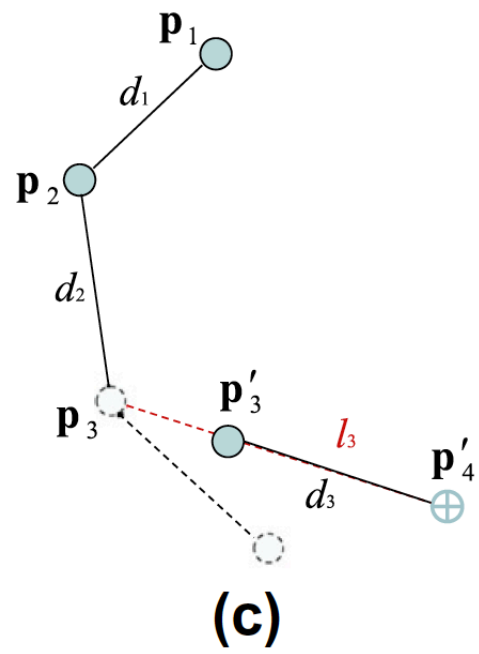
Forward and Backward pass

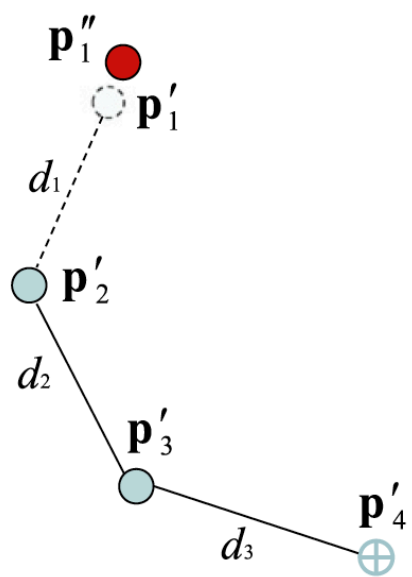
- Move the end-effector to t , i.e. $p_n = t$
- For each of the previous point p_i , $i = n-1$ to 1 :
find the vector $(p_{i+1} - p_i)$, and the new position, p_i as the relative position of that joint along this vector.
- Now, our root p_i would be somewhat shifted from its initial position b , set $p_1 = b$
- For each of the next point p_i , $i = 1$ to $n-1$:
Find the vector $(p_i - p_{i+1})$, and the new position, p_{i+1}' as the relative position of that joint along this vector.
- Update the new diff = $|p_n - t|$



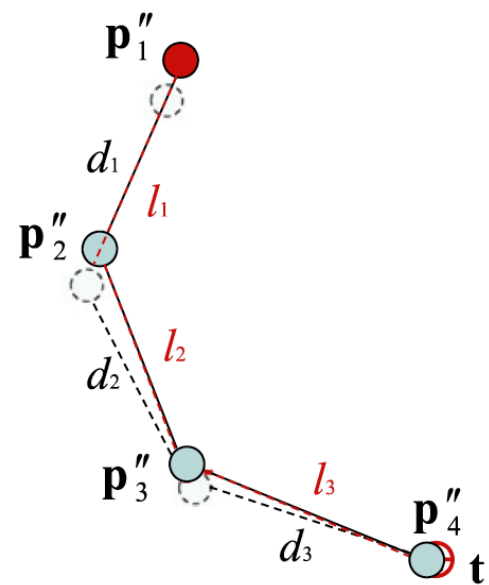
\mathbf{t}
 \oplus







(e)



(f)

FABRIK with multiple end effectors

