ロボットアームの順運動学: 原理
Robot Arm Forward Kinematics: Principle

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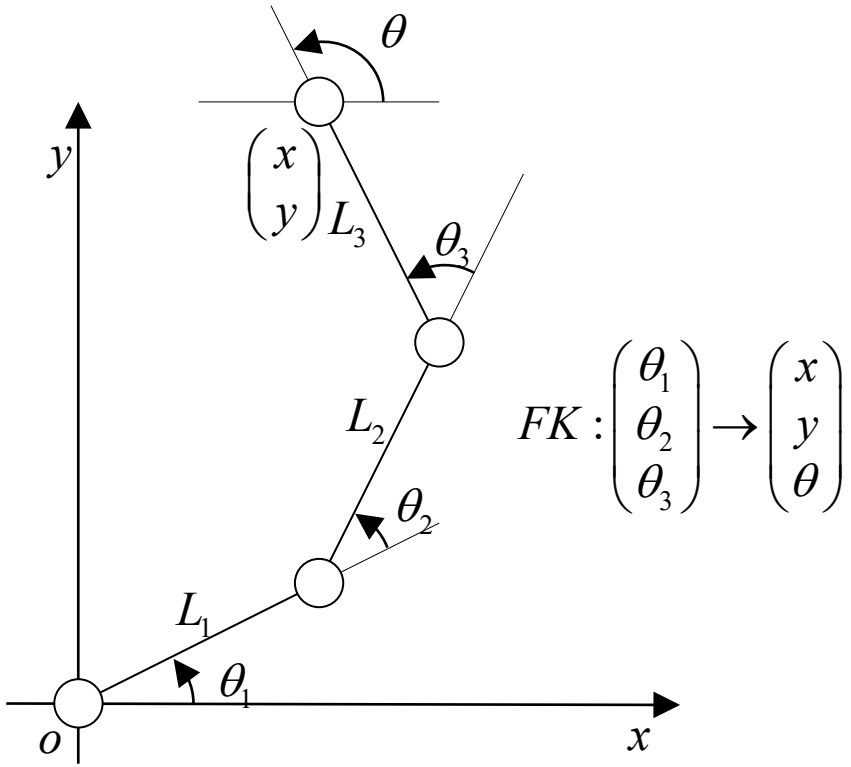
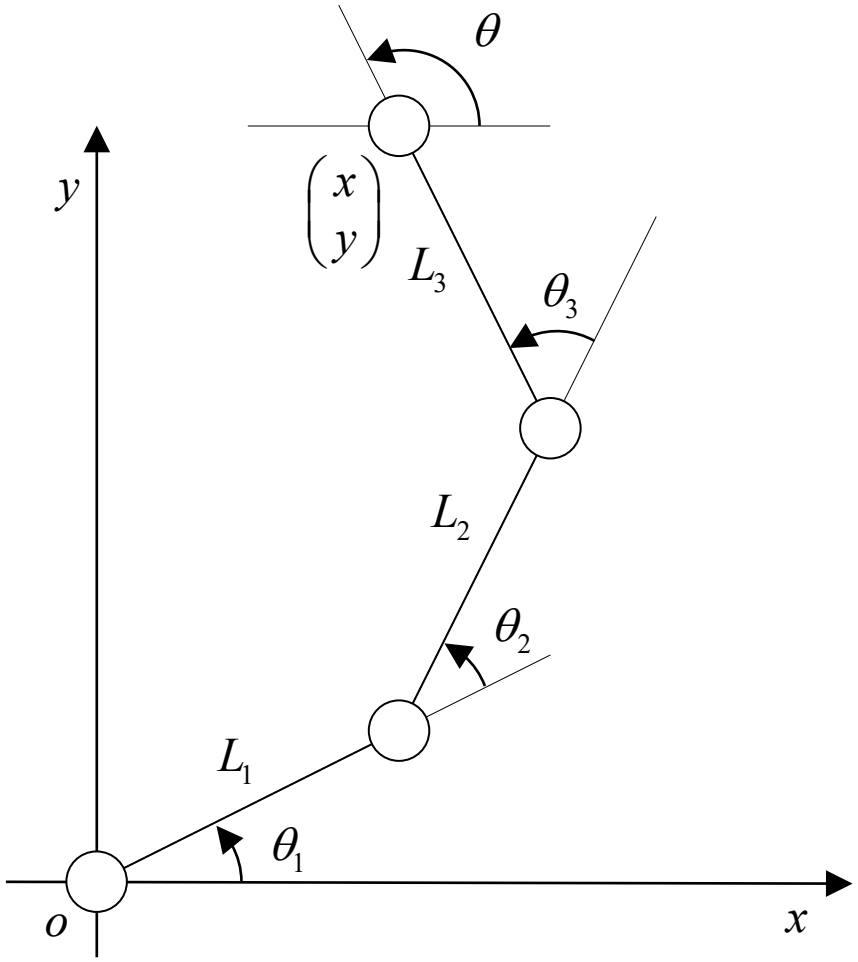


$$FK: \begin{pmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \end{pmatrix} \rightarrow \begin{pmatrix} x \\ y \\ \theta \end{pmatrix}$$

まとめ
- 順運動学：関節角度からロボットアームの姿勢（位置と向き）を求めること

Summary
- Forward kinematics: From joint angles to robot arm pose (position and orientation)

ロボットアームの順運動学
Forward Kinematics of Robot Arm

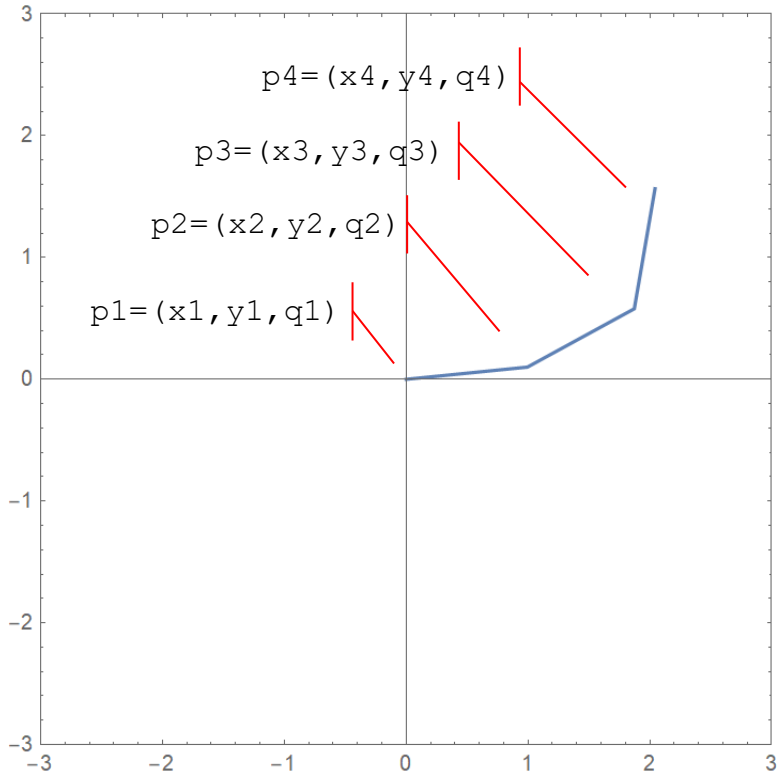


順運動学
- 入力：各関節角度
- 出力：各参照点（手先，関節）の姿勢（位置と向き）
- 解を閉じた形式で表現できる

Forward kinematics
- Given: A set of joint angles
- Find: A set of poses (position and orientation) of reference points such as a hand tip and joints
- We can find it in a closed form

$$x = f_x(\theta_1,\theta_2,\theta_3) = L_1\cos\theta_1 + L_2\cos(\theta_1+\theta_2) + L_3\cos(\theta_1+\theta_2+\theta_3)$$
$$y = f_y(\theta_1,\theta_2,\theta_3) = L_1\sin\theta_1 + L_2\sin(\theta_1+\theta_2) + L_3\sin(\theta_1+\theta_2+\theta_3)$$
$$\theta = f_\theta(\theta_1,\theta_2,\theta_3) = \theta_1+\theta_2+\theta_3$$

平面3リンクロボットアームの順運動学のサンプルコード
Sample Code of Forward Kinematics of Planar 3-Link Robot Arm



マセマティカによるサンプルコード（一部のみ）
Sample code in Mathematica (Only a part)

```
FK[q_]:=
 Module[{p1, p2, p3, p4},
  p1 = {0,0,0};
  p2 = p1+{L1 Cos[q[[1]]],L1 Sin[q[[1]]],q[[1]]};
  p3 = p2+{L2 Cos[q[[1]]+q[[2]]],L2 Sin[q[[1]]+q[[2]]],q[[2]]};
  p4 = p3+{L3 Cos[q[[1]]+q[[2]]+q[[3]]],L3 Sin[q[[1]]+q[[2]]+q[[3]]],q[[3]]};
  {p1,p2,p3,p4}
 ];
q = {0.1, 0.4, 0.9}
p = FK[q]
ListPlot[{p[[1,1;;2]], p[[2,1;;2]], p[[3,1;;2]], p[[4,1;;2]]},
 Joined -> True,
 PlotRange -> {{-3, 3}, {-3, 3}},
 Frame -> True,
 AspectRatio -> 1]
```

Code is available at https://github.com/keitaronaruse/Naruse-robotics-tutorial/blob/main/src/mathematica/FK-3LinkPlanarArm.nb

マセマティカの順運動学コードのデモンストレーション
Demonstration of Mathematics Forward Kinematics Code