

Intuitive (?) Boundary-tracing Procedure for Finding a Manipulator's Workspace

1. Start at a known point on the workspace boundary (e.g., where the manipulator is at maximum reach and/or where all constrained joints are at their limits). This point will be referred to as the first “critical point.”
2. Generate feasible workspace boundary segments by varying one joint at a time away from the critical point over the joint's full range of motion and by tracing the resulting end-effector path (arc or line segment). The end-points of the segments will be referred to as additional “critical points.” Avoid drawing segments and critical points that are obviously within the workspace interior (i.e., the end-effector can move to both sides of the segment); otherwise, deal with these in step 6.
3. Repeat step 2 recursively for each of the new critical points until all feasible critical points and boundary segments have been checked.
4. Identify any distinct “tangency points” on the candidate boundary segments where end-effector motion due to a revolute joint is parallel to motion due to other joints (e.g., at a revolute joint 0° or full extension point, or where a revolute joint's end-effector motion is parallel to a prismatic joint's motion). Process these points as critical points in step 2.
5. At this point, all feasible workspace boundary segments will be drawn.
6. Resolve boundary segment intersections (eliminate false interior segments where motion is possible on both sides of the segment) and identify the interior by looking at possible motion from the boundary segments in neighborhood around the critical points.