

28. Quasidynamic parts orienting

Mechanics of Manipulation

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Outline.

- What is “quasidynamic”?
- Demonstrate tray tilting.
- Analysis of wrench in corner; of wrench at bottom.
- Analysis of wrench in uncertain pose.

Quasidynamic

Remember the peg in hole problem?

Static analysis: identify jamming and wedging conditions, and avoid them.

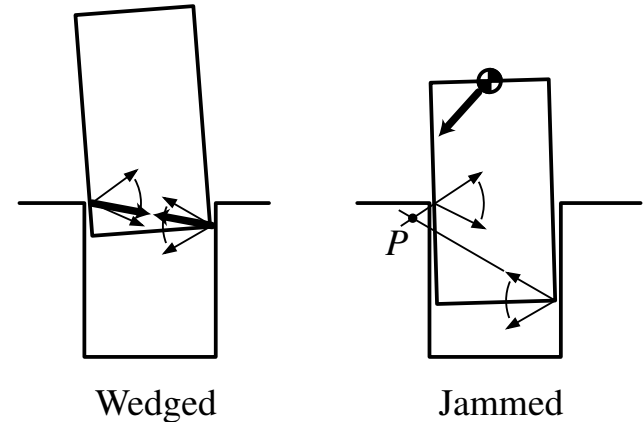
Quasistatic analysis: not applicable. Non-jamming applied force is balanced only by dynamic load.

Dynamic analysis: too hard. Doubles the state variables.

Quasidynamic

Assume velocity is negligible.

Solve for acceleration, assume object moves in direction of acceleration.



Tray tilting

Assumptions

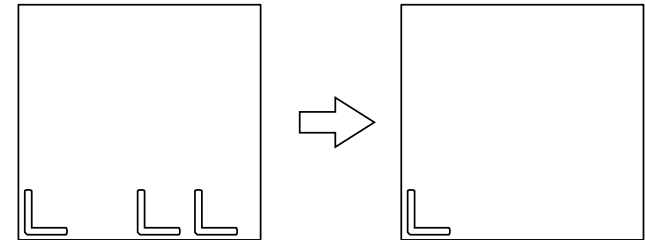
1. Rigid body Newtonian mechanics with Coulomb friction.
2. Known shapes, mass distribution, coefficient of friction.
3. Friction with floor of tray is negligible.
4. Quasidynamic ...
 - Centripetal acceleration is negligible.
 - Impact: object just stops.

Goal for example plan

Initially wrench is oriented, and anywhere along the bottom wall.

Goal is for wrench to be in same orientation, in lower left corner.

Find a single action, a single applied force, that accomplishes the goal.



Plan of attack

Remember ambiguities. We cannot just look at the desired contact mode to find a good tilt angle. We have to exclude all the undesired contact modes.

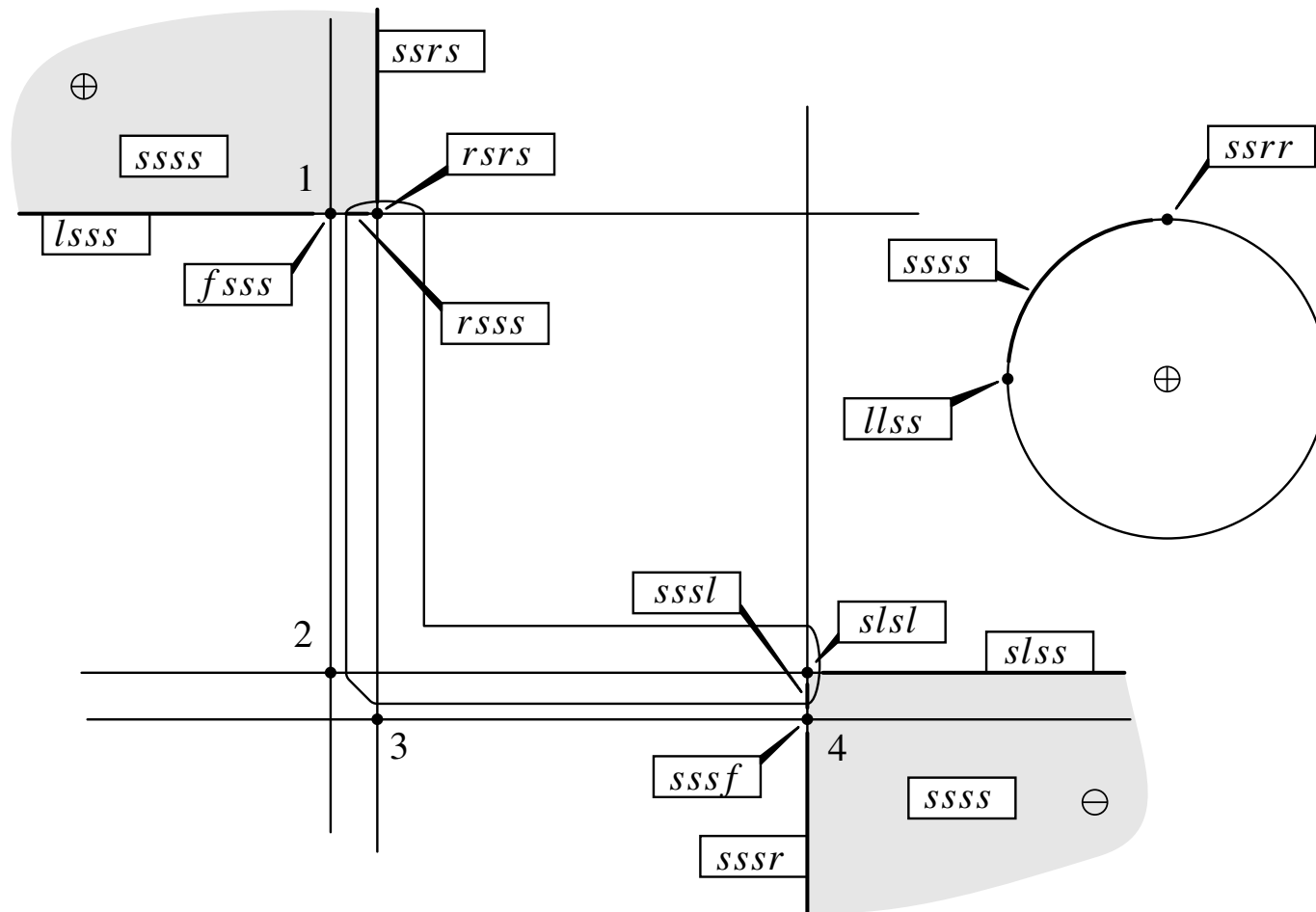
For every possible initial configuration . . .

For every undesired contact mode

Exclude the tilt angles

If any tilt angles are not excluded by some contact mode for some initial configuration, then you have an action that produces the desired contact mode for every possible initial configuration.

Recall contact modes for wrench in corner



Recall analysis of mode “rsrs”

We used force dual:

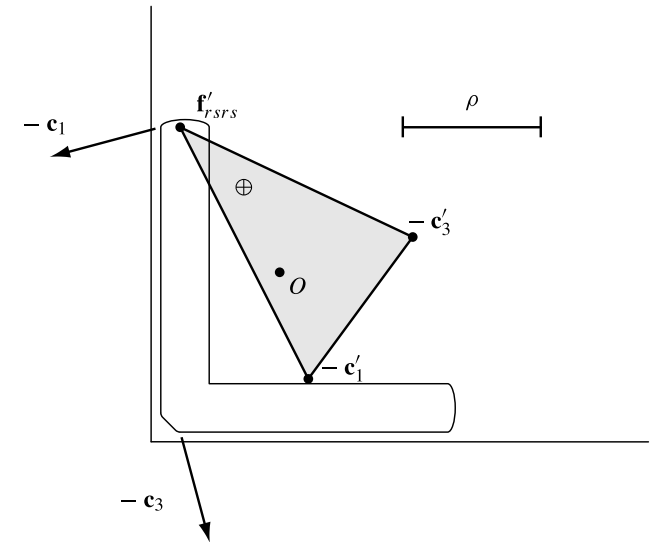
Represent dynamic load by acceleration center

Transform negated contact forces by force dual

Find positive linear span of force dual and negated contact forces

Result is candidate applied forces

Intersect with line at infinity to get tilt directions



Analysis of mode “ssrr”

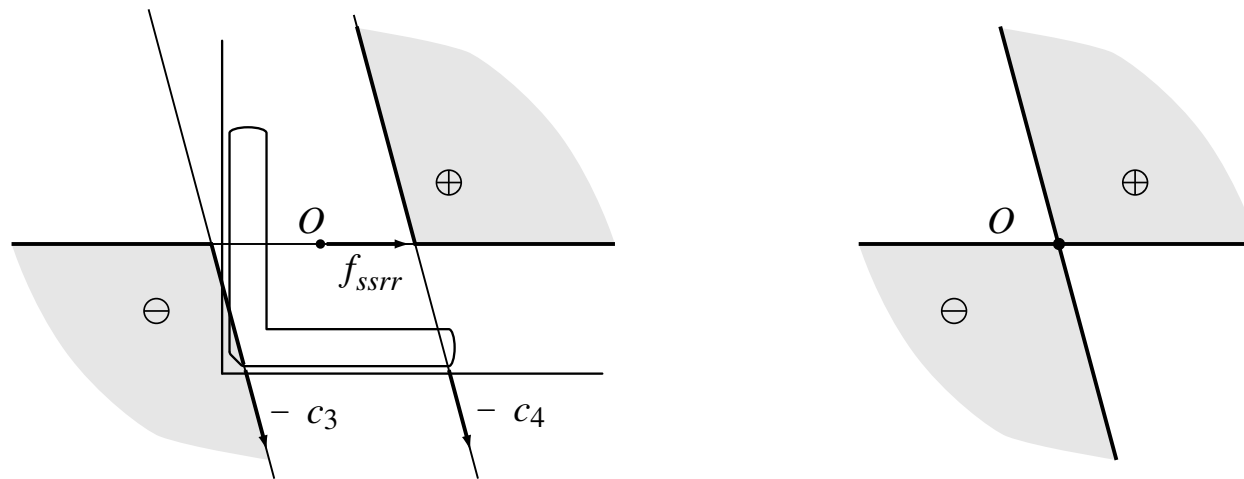
We'll use moment labeling

Transform acceleration center to dynamic load line of force

Find positive linear span of dynamic load and negated contact forces

Result is candidate applied forces

Intersect with wrenches through COM to get tray tilt directions.

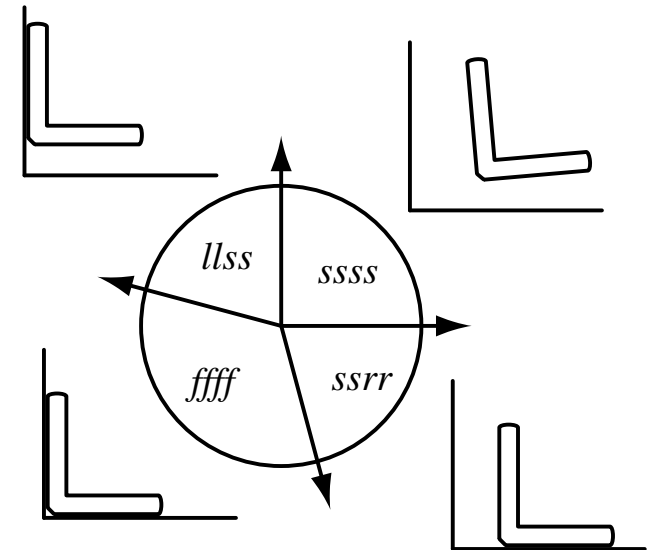


All possible actions from lower left corner

Analyze the other modes.

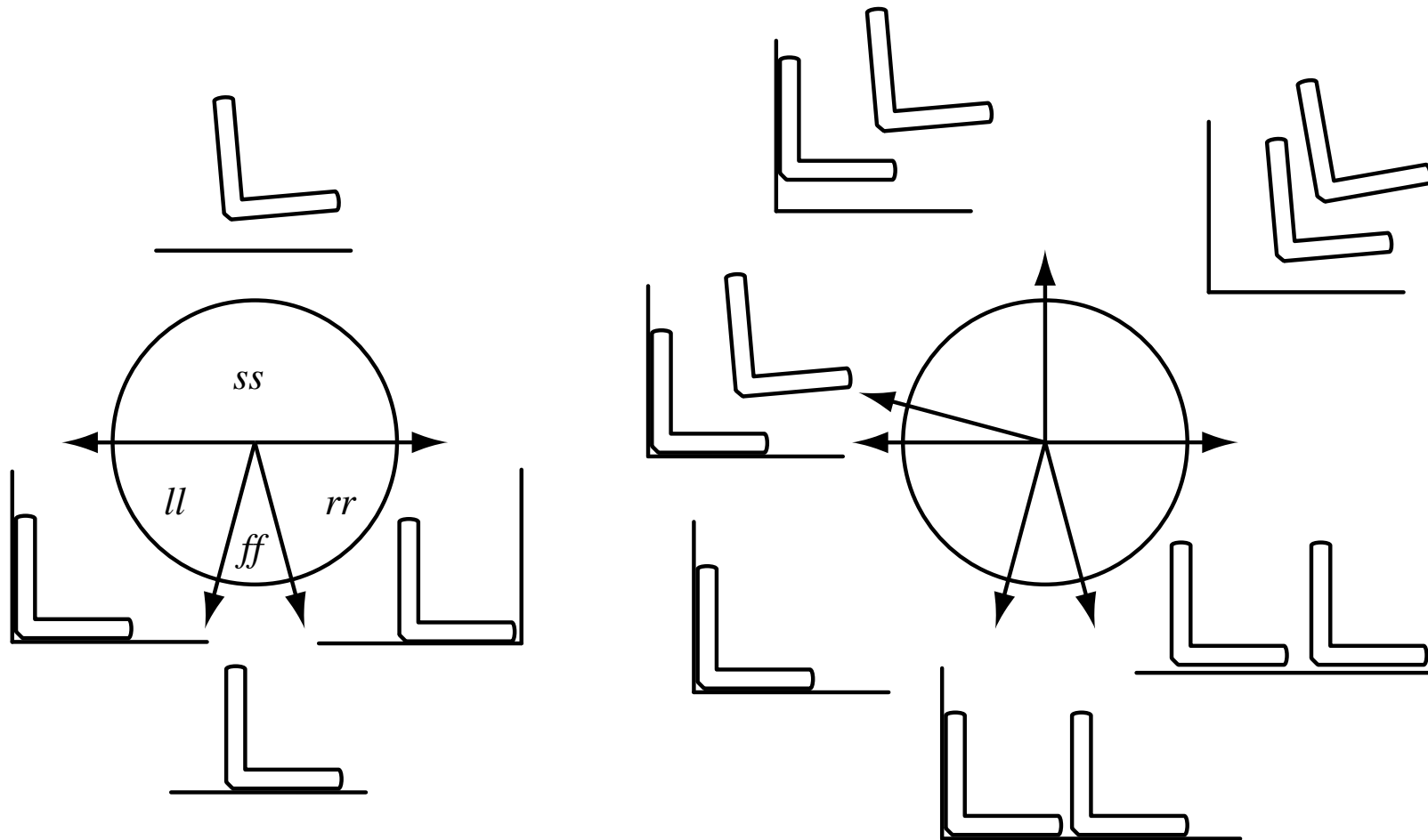
Record all modes corresponding to wrenches through COM

In this case, no ambiguities



Analysis of wrench on bottom wall

Do the same thing for the wrench against the bottom wall, and intersect



Parts orienting

Assume initial location of object is everywhere: any orientation, any place in the tray.

Goal is for it to be somewhere. Some particular somewhere.

For every pose and every contact mode, identify the corresponding tilt angles.

Define a graph.

- Each node is a set of configurations.

- Each edge is a range of tilt angles, the tilt angles that map the wrench from the source node configurations to the sink node configurations.

- The root is the set of all configurations.

Do a breadth-first search of the tree. When you reach a node with just one configuration, you're done.

How big is the tree? In theory, it could be big. In practice, it's not.

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