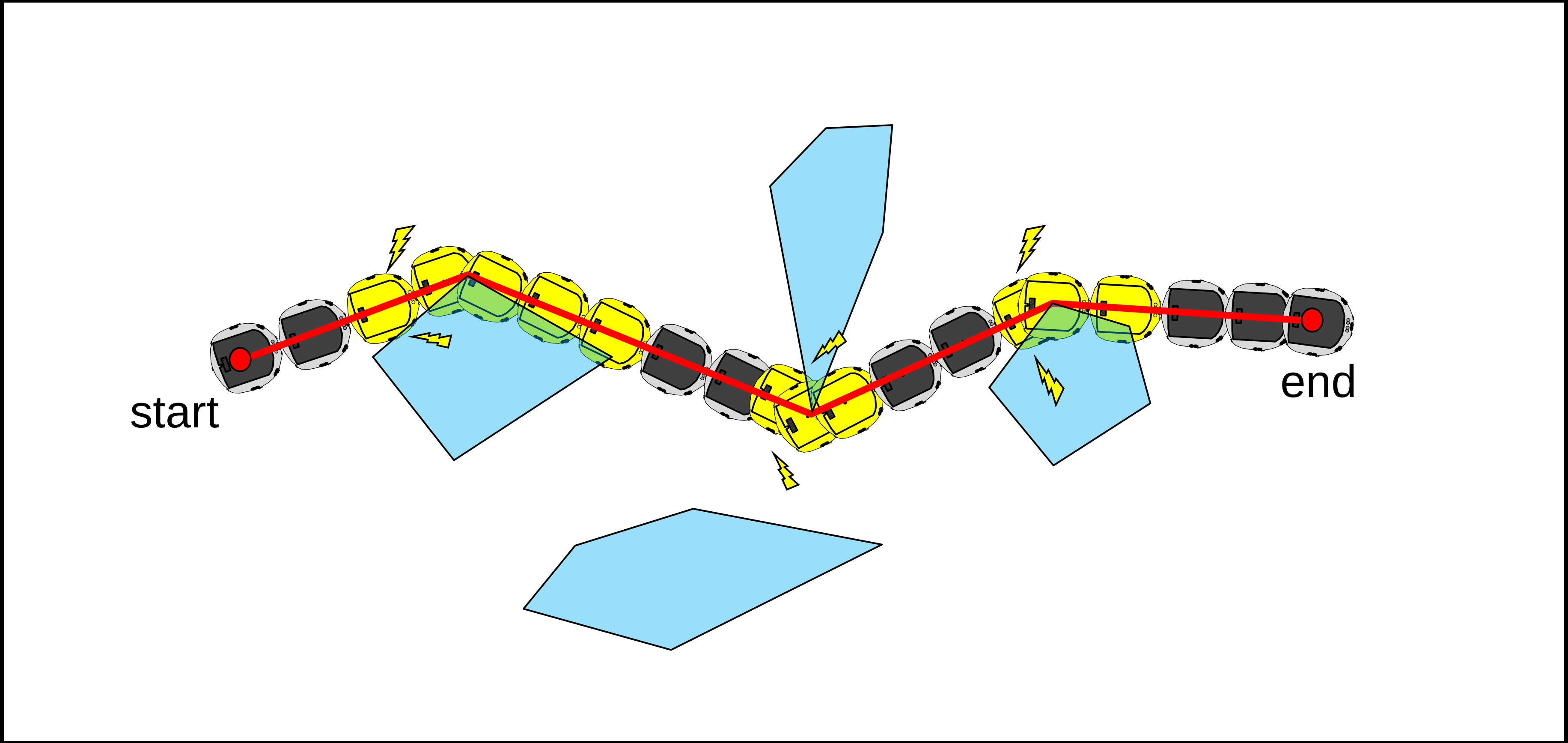
Grown Obstacle Space

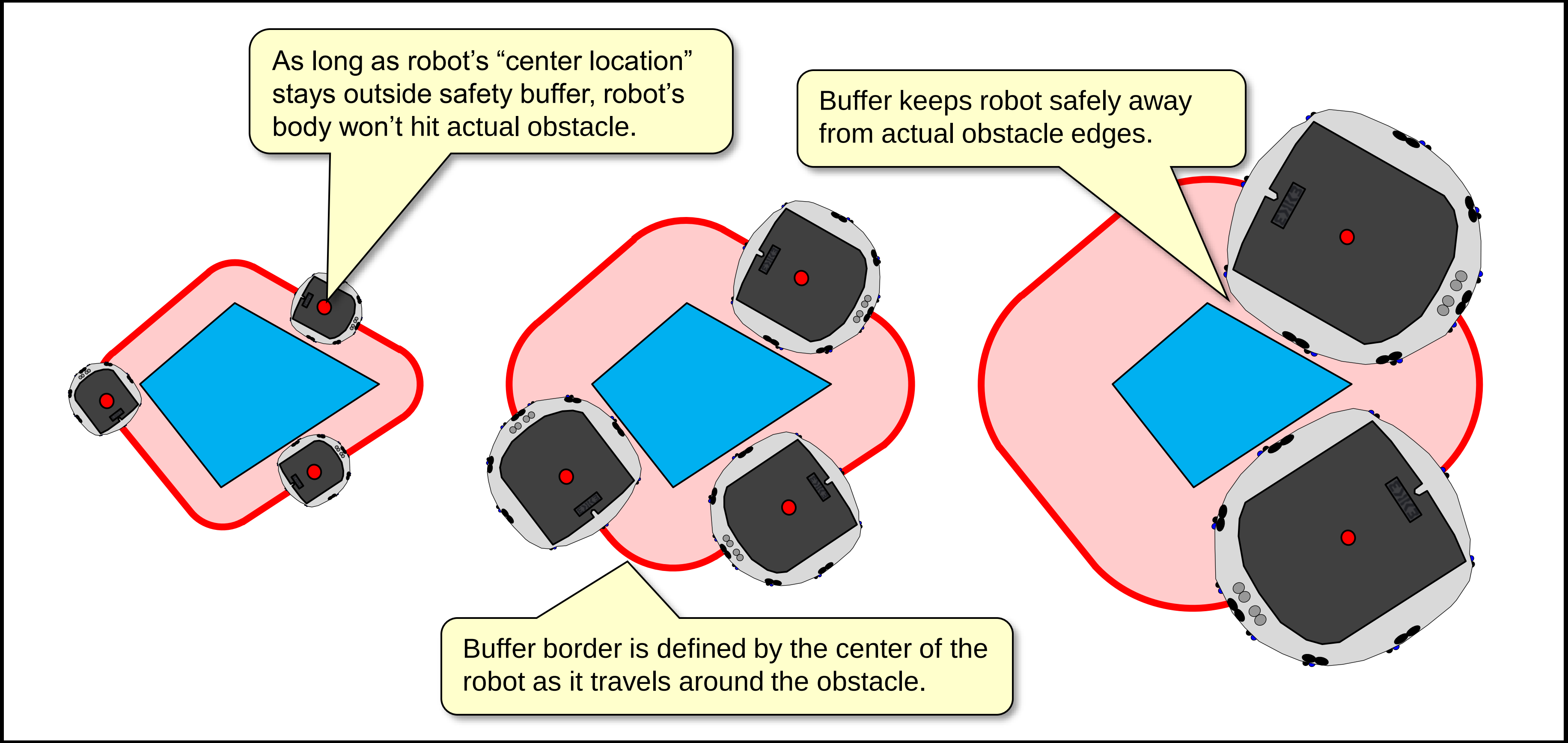
Shortest Path Problems

- Any real robot will collide with obstacles if it travels along our computed shortest path because we assumed that the robot was just a point, but a robot has a shape:



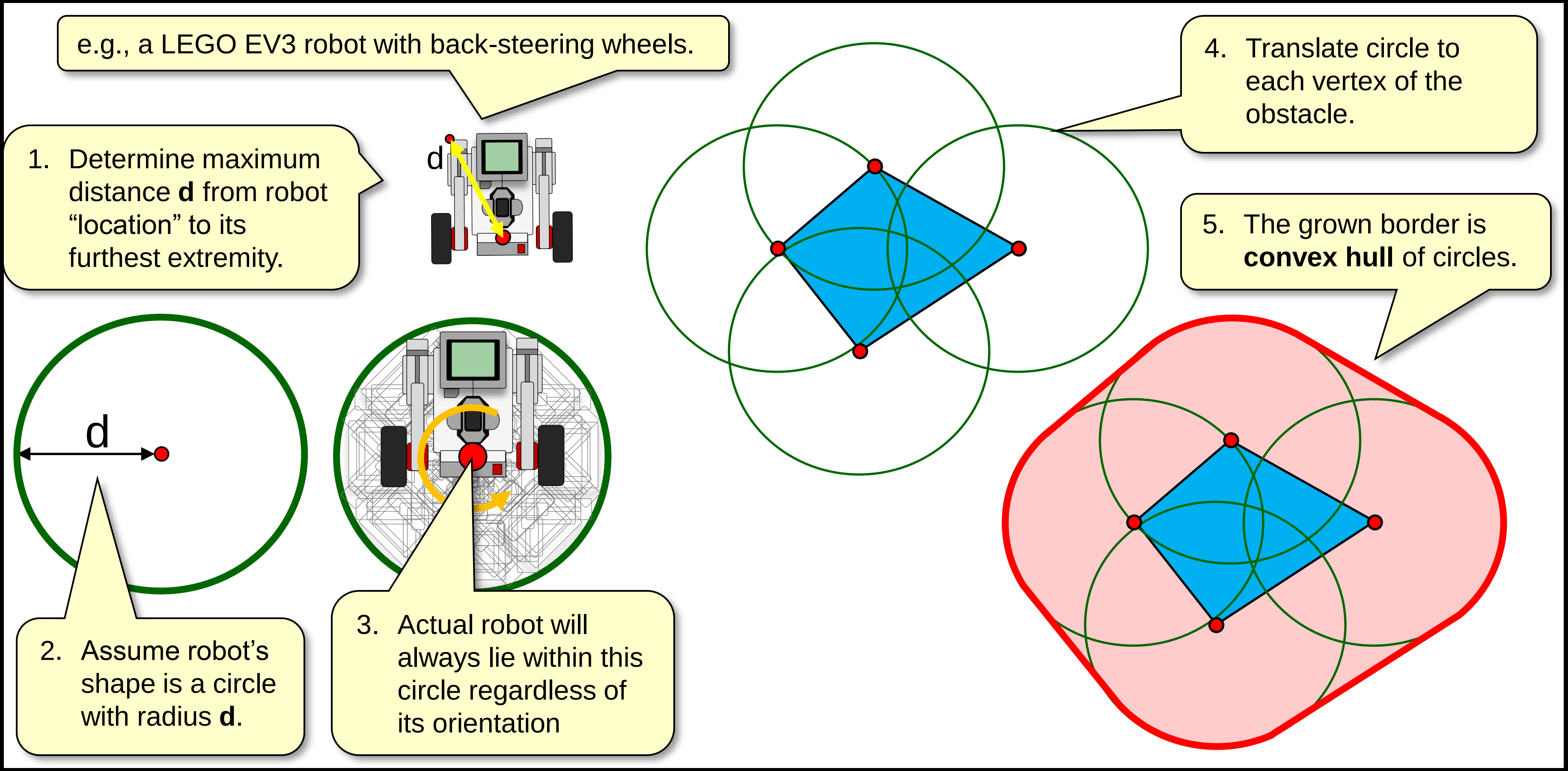
Safety Buffers

- Need to have a “safety buffer” around the obstacles which takes into account robot’s size and shape.



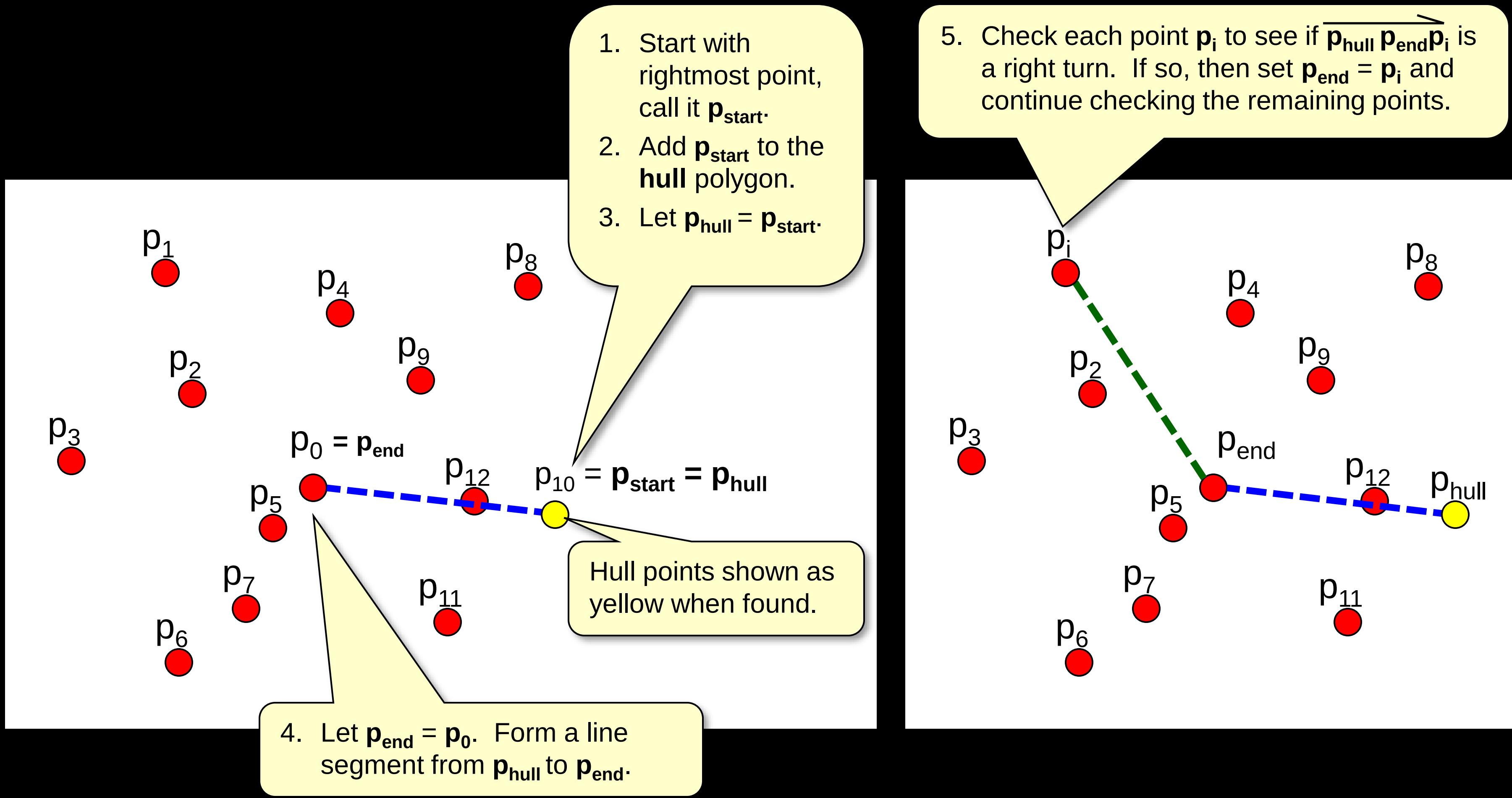
Grown Obstacle Space

- Must "grow" obstacles by amount that considers any orientation of robot at any point on obstacle border:

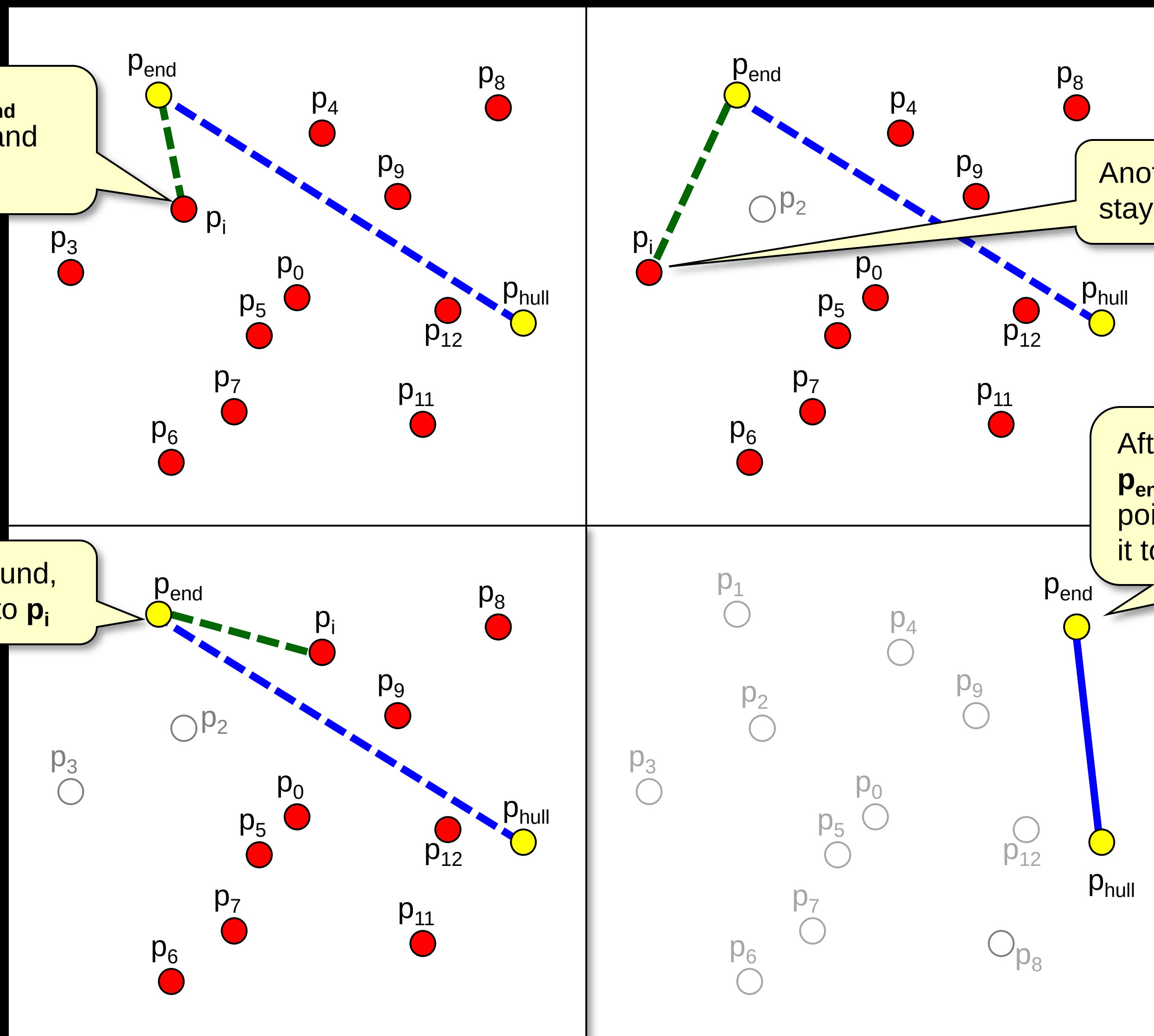


Computing the Convex Hull

- Algorithms exist to find convex hull of a set of points
  - Graham Scan (a.k.a. “Gift-Wrapping” method) is a simple one:

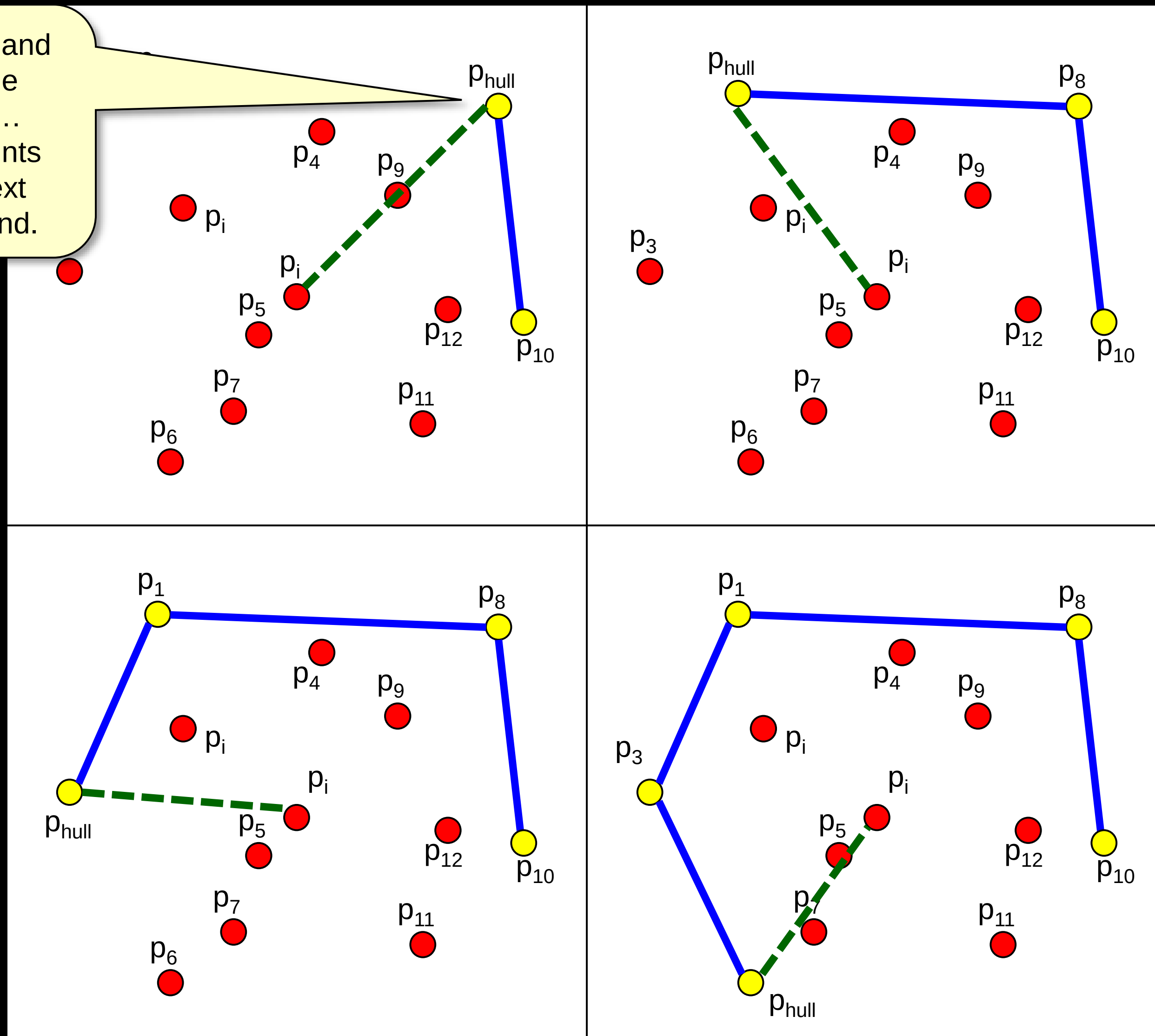


Computing the Convex Hull

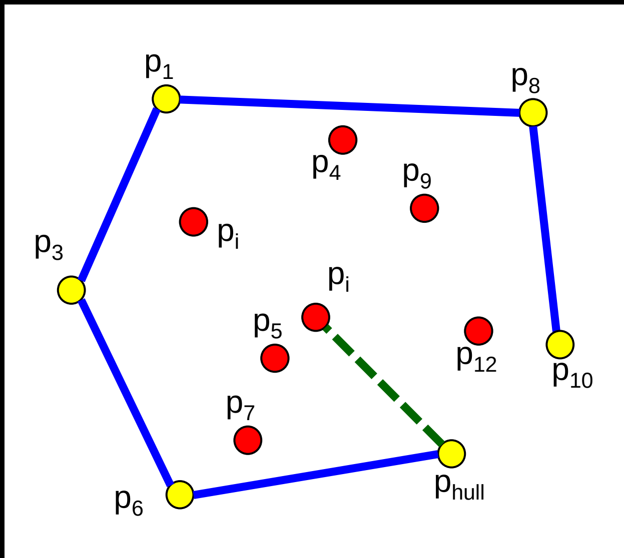


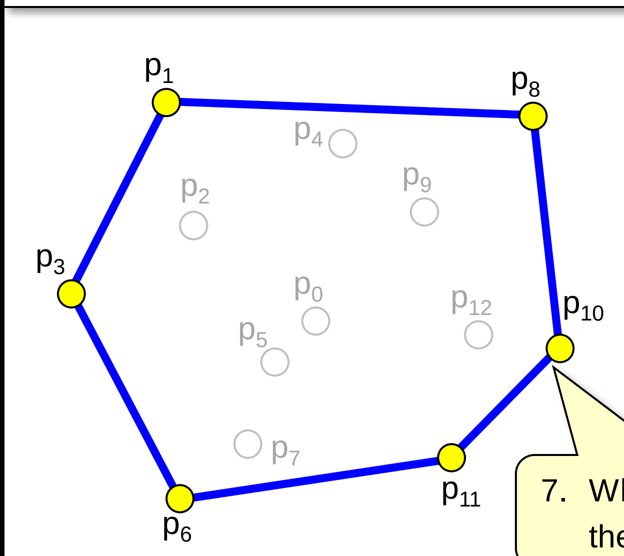
Computing the Convex Hull

6. Set $\mathbf{p_{hull}}$ = $\mathbf{p_{end}}$ and repeat the whole process again … checking all points in order until next hull point is found.



Computing the Convex Hull






```
FUNCTION ConvexHull(PointList points)
    hull = an empty list
    pHull = the rightmost point in points
    pStart = pHull
    pEnd = NULL
    WHILE (pEnd is not equal to pStart) DO
        Add pHull to hull
        pEnd = the first point in points
        FOR (each point pi in points) DO
            IF (pHull is the same as pEnd) THEN
                pEnd = pi
            IF (angle pHull to pEnd to pi is a right turn) THEN
                pEnd = pi
        pHull = pEnd
    RETURN hull
```

Special case

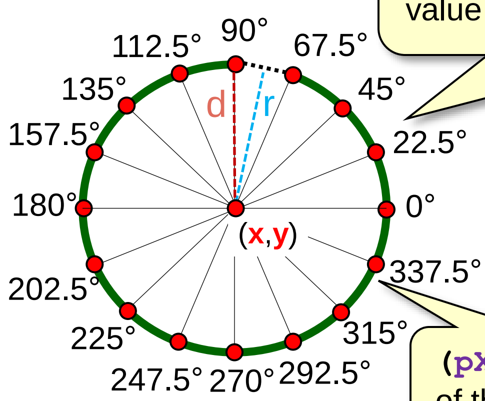
it is a right turn only if

$((pEnd_x - pHull_x)*(pi_y - pHull_y) - (pEnd_y - pHull_y)*(pi_x - pHull_x)) < 0$

7. When $\mathbf{p_{end}} = \mathbf{p_{start}}$ then we are done.

Convex Hulls Around Obstacles

- Find Convex Hull of “points circles” around obstacle vertices:

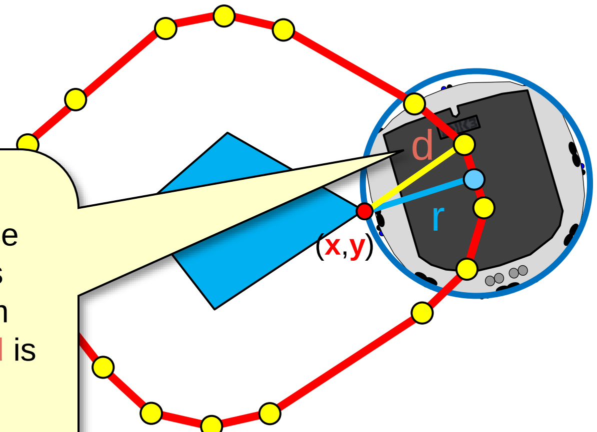


Decide upon how many points you want on the circle by setting a **DEGREE_UNIT** value (e.g., 22.5° shown here).

(pX,pY) is one of the points.

Given a robot radius of r, then points must be at least distance d from (x,y) so that robot does not collide when travelling from one vertex to another, where d is

$$\frac{r}{\cos\left(\frac{\text{DEGREE\_UNIT}}{2}\right)}$$

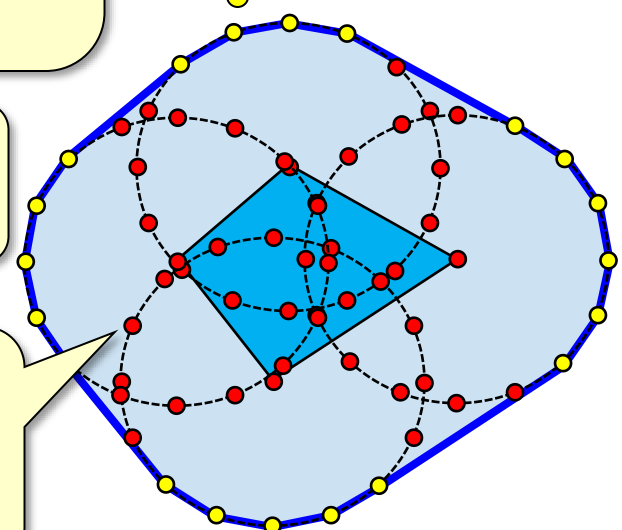



```
circlePoints = empty list

FOR (a=0; a<360; a+=DEGREE_UNIT) DO {
  xoff = d*cos(a)
  yoff = d*sin(a)
  if (xoff > 0) pX = x + ceil(xoff)
  otherwise pX = x + floor(xoff)
  if (yoff > 0) pY = y + ceil(yoff)
  otherwise pY = y + floor(yoff)
  add point (pX, pY) to circlePoints
}
```

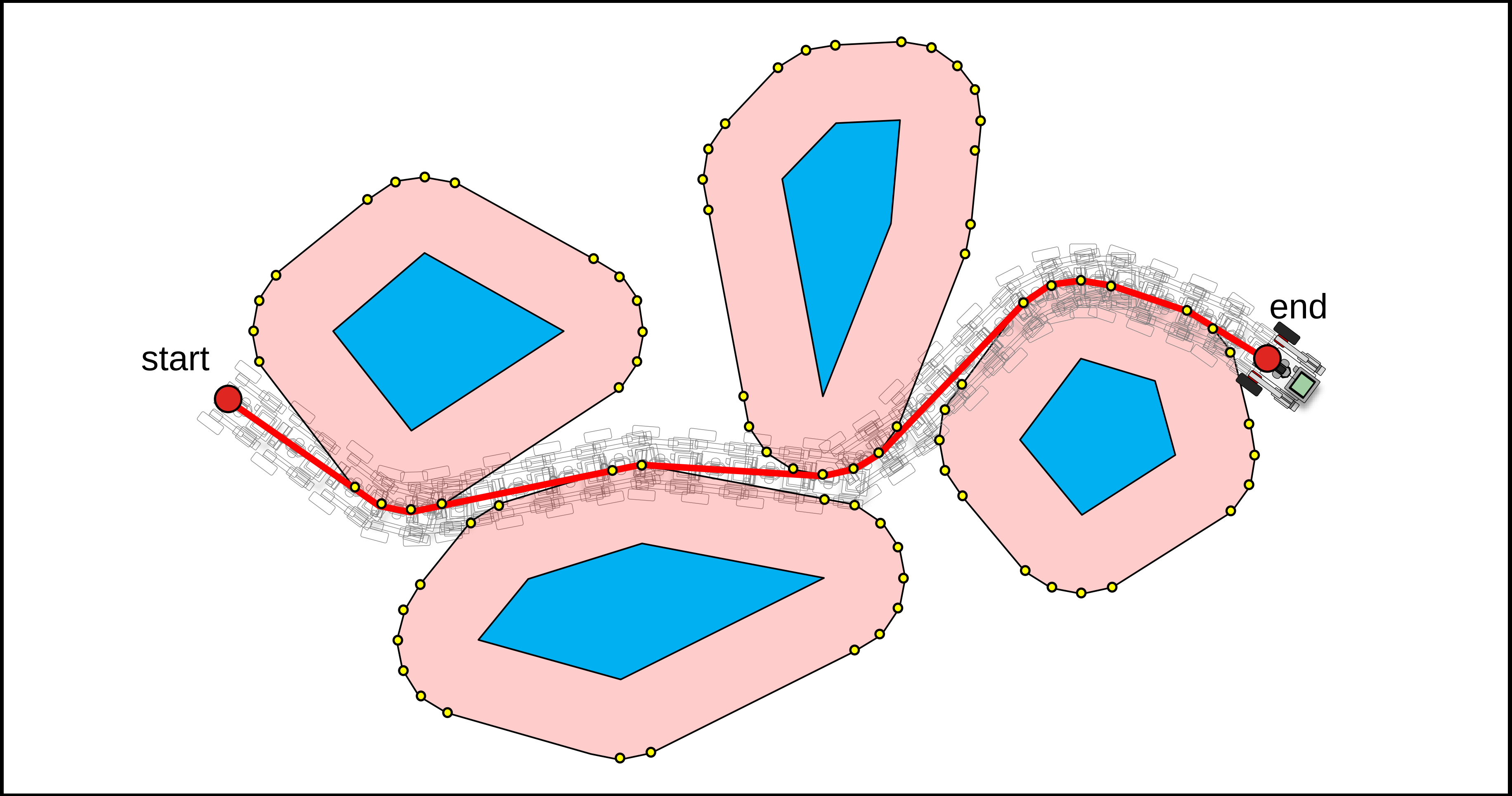
Create a list of **circlePoints** centered around an obstacle vertex (x, y) as shown here.

Merge all **circlePoints** lists from each vertex (x, y) of the obstacle. Using this “merged” list of points … find the convex hull.



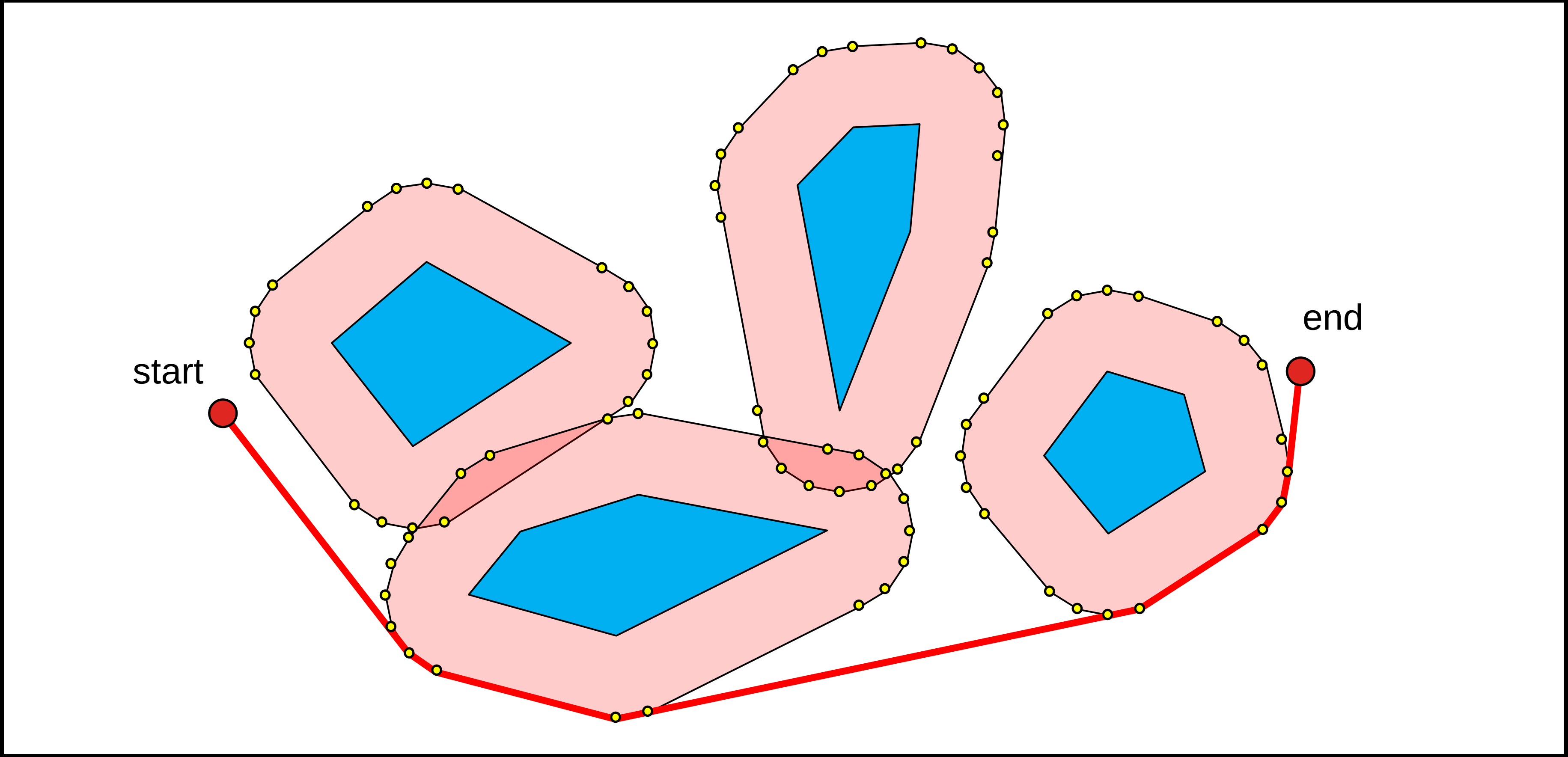
Real Robot Shortest Path

- Now the robot has collision-free travel



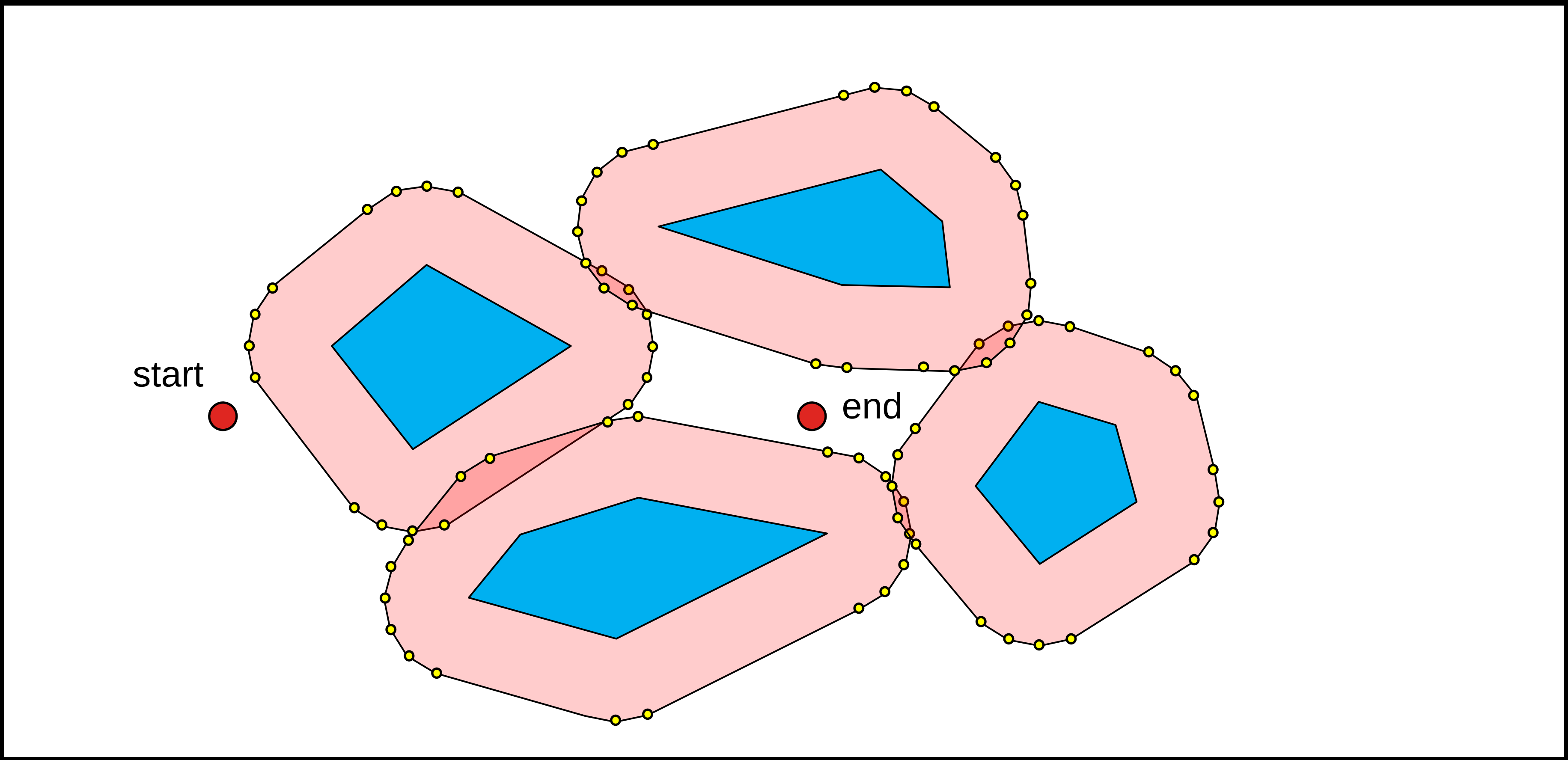
Real Robot Shortest Path

- In some cases, the grown obstacles will intersect, resulting in a different solution path.



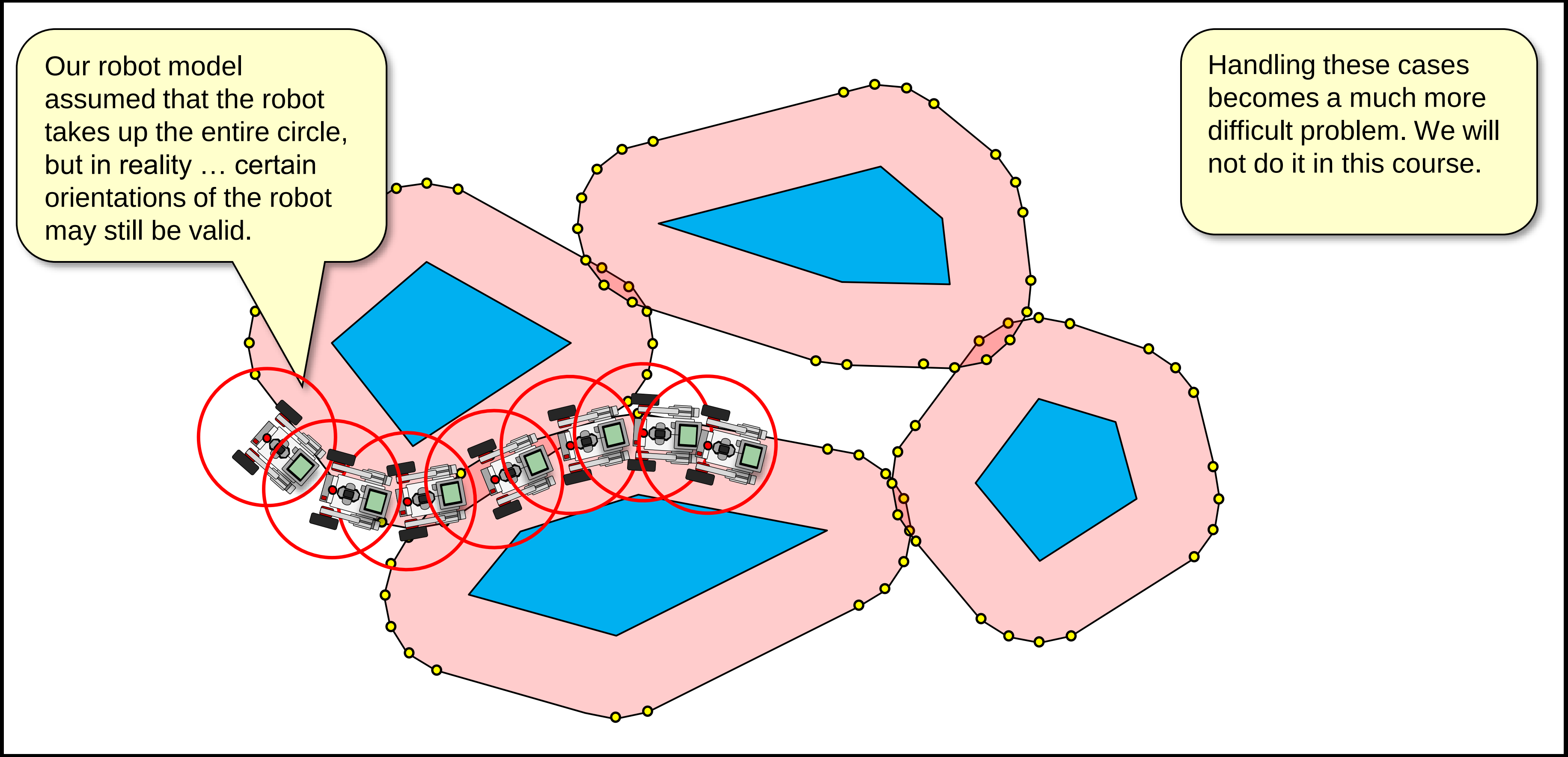
Real Robot Shortest Path

- In some cases, there may even be no solution !



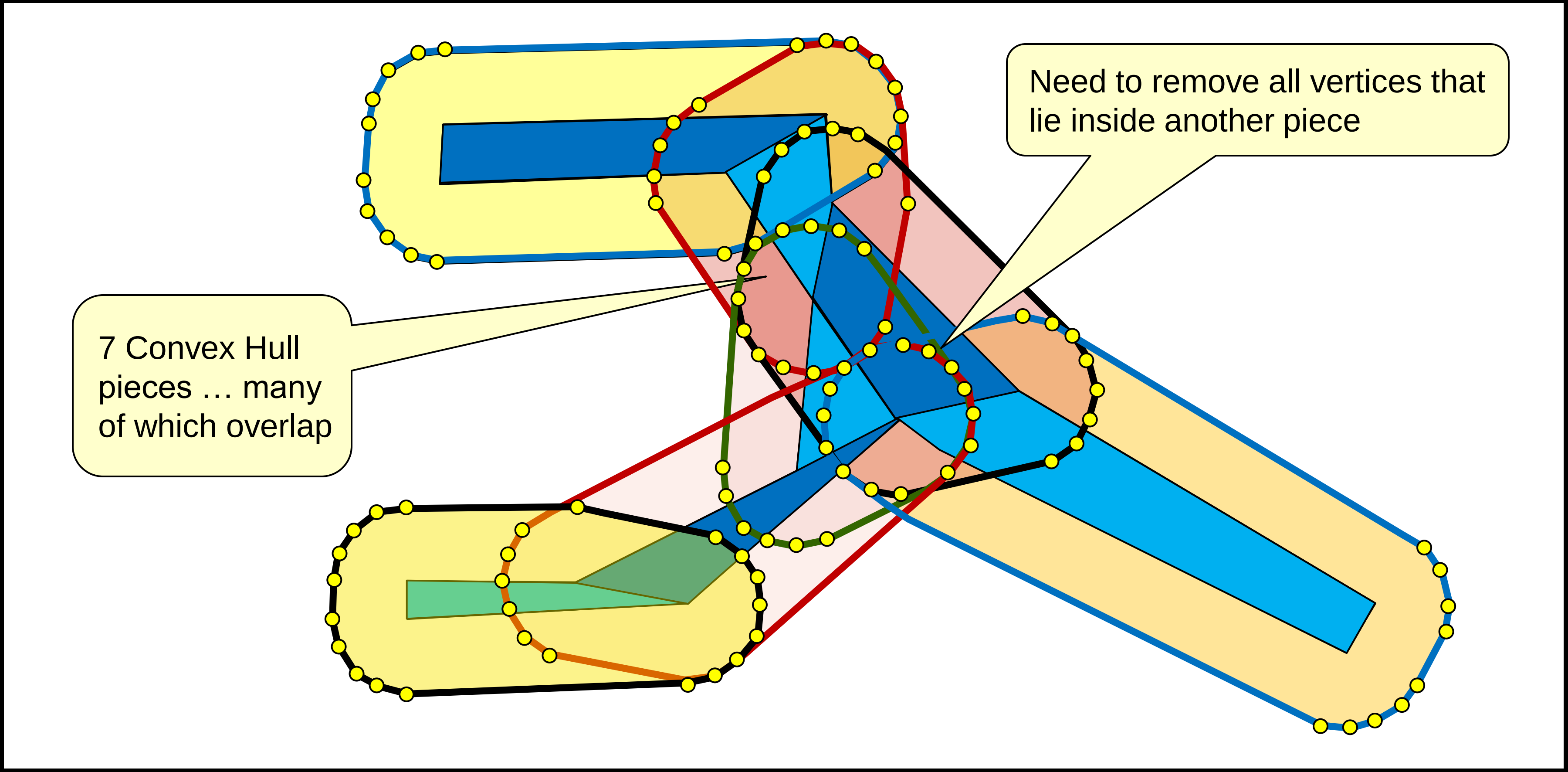
Real Robot Shortest Path

- However, this is a restriction on our robot model and algorithm, as actual robot can “fit”:



Non–Convex Solution

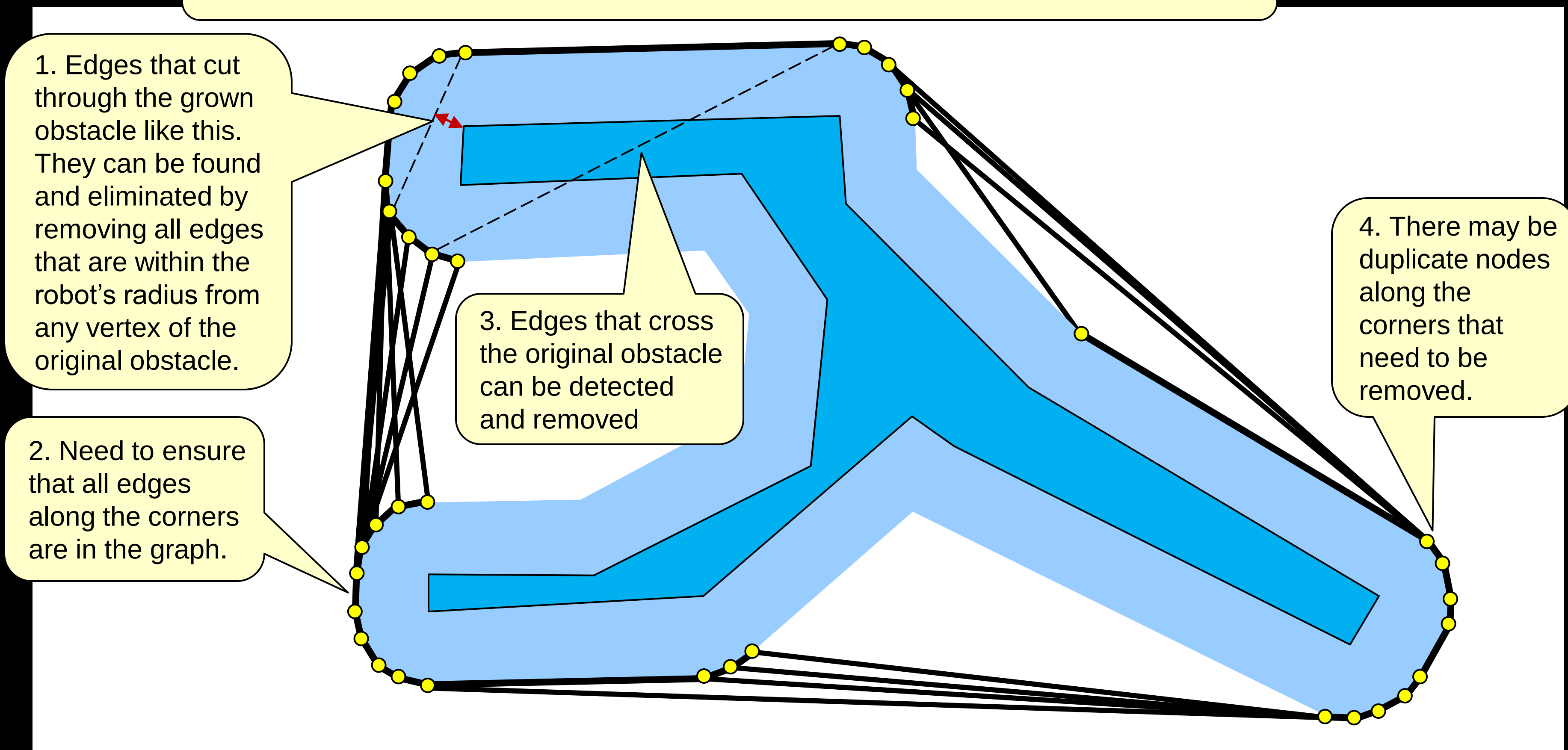
- Compute Convex Hull for each piece:



Non–Convex Challenges

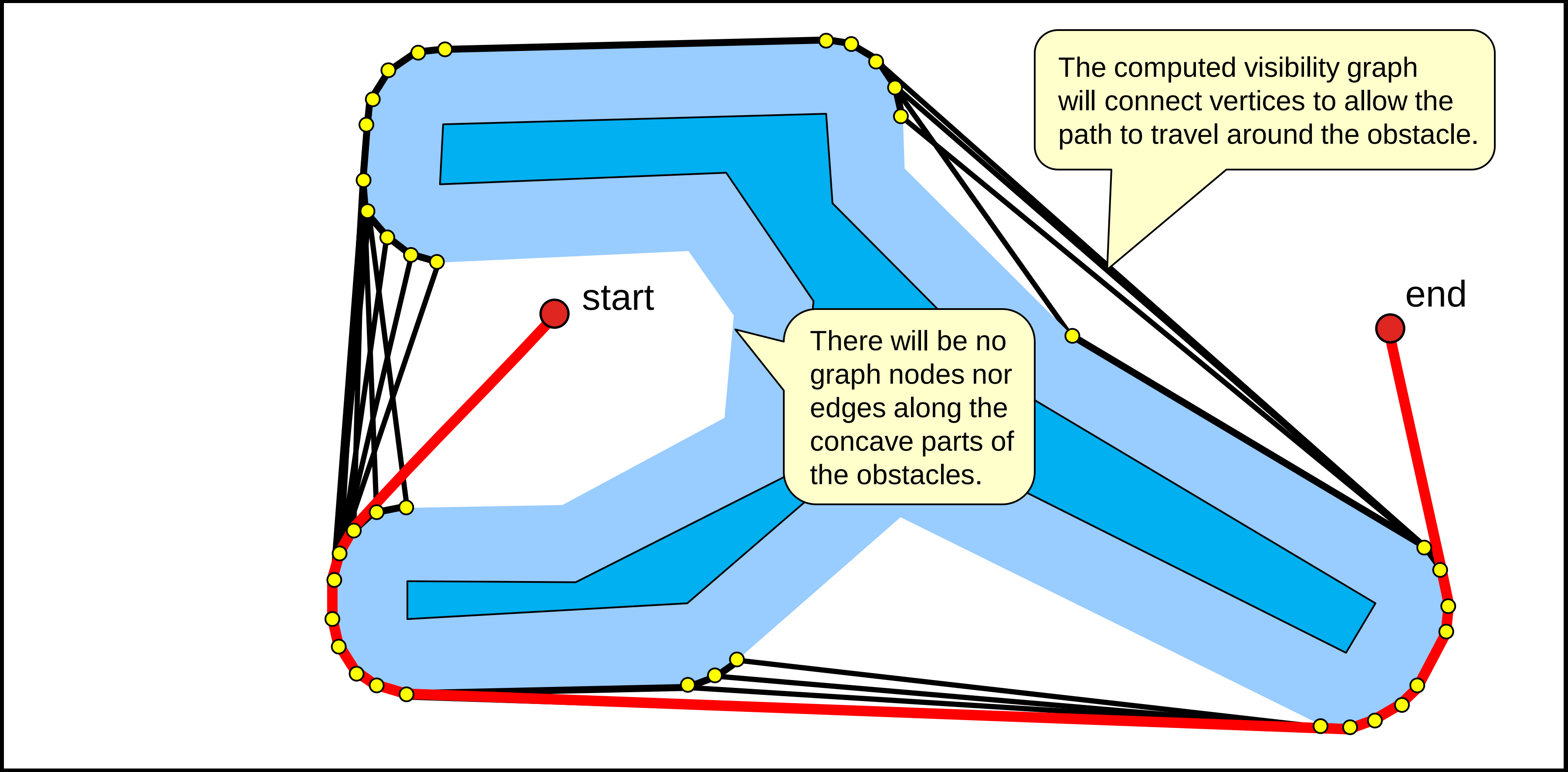
- Compute visibility graph … but it is tricky:

Unfortunately, there are a lot of intersection-related problems that pop up due to the overlapping of the various convex pieces. This will require the coding of special cases.



Non–Convex Shortest Path

- If done correctly, the shortest path can be found:



Start the Lab …