Note Title 2/23/2012

Lecture 13

Numerical Potential Fields

Discrete : give up continuity

Continuous Navig. also possible, but in restrictive domains :

all obs. are circles, then yes

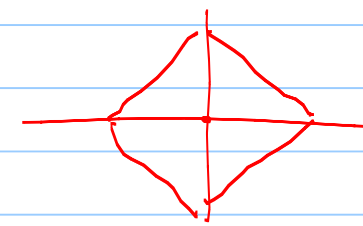
Case 1 : NF1

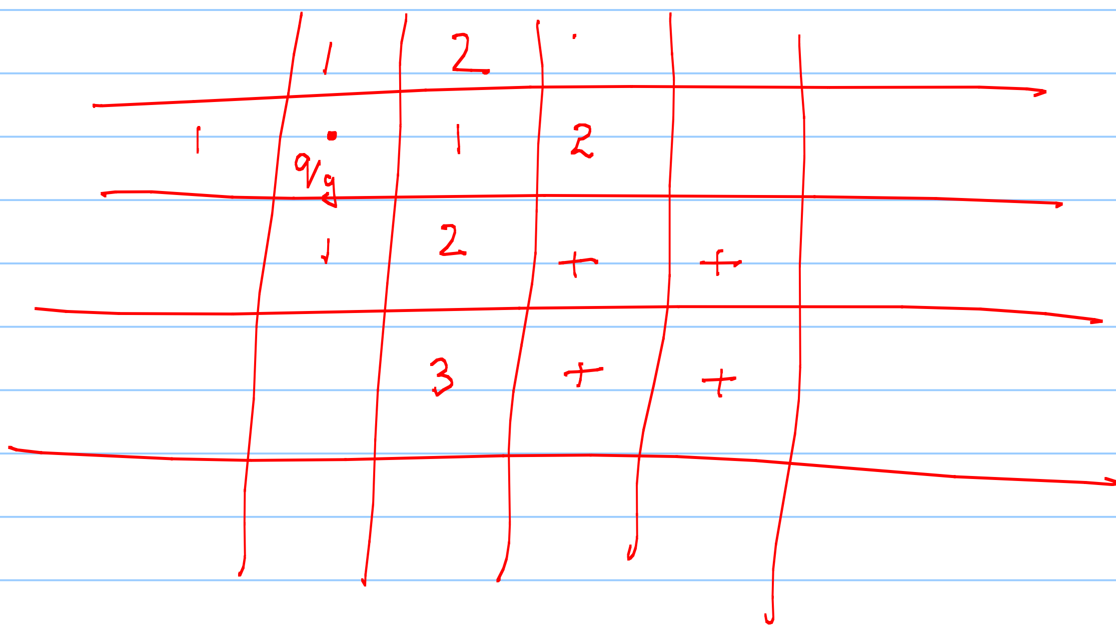
1) lay a grid over workspace

$L^1 = |x_2 - x_1| + |y_2 - y_1|$

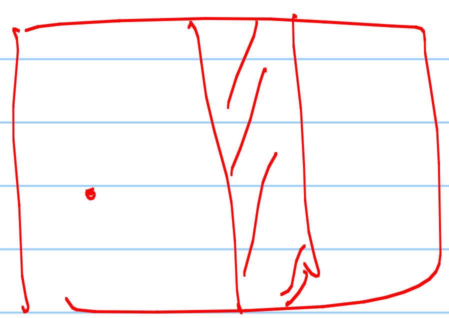
$1 \rightarrow$ obs

$0 \rightarrow$ free





2) Expand in a wavefront manner from q_g, filling each pixel with the corr. L_1 dist. value from q_g until q_i is reached or [entire workspace] pixels have a value assigned
("connected component" in which q_g lies)



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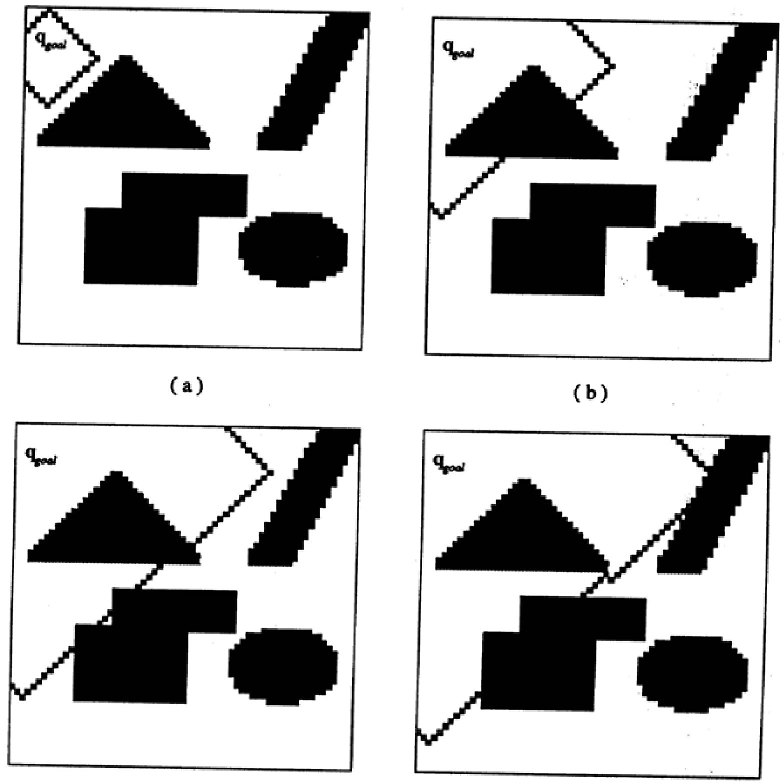

(a) (b) (c) (d)

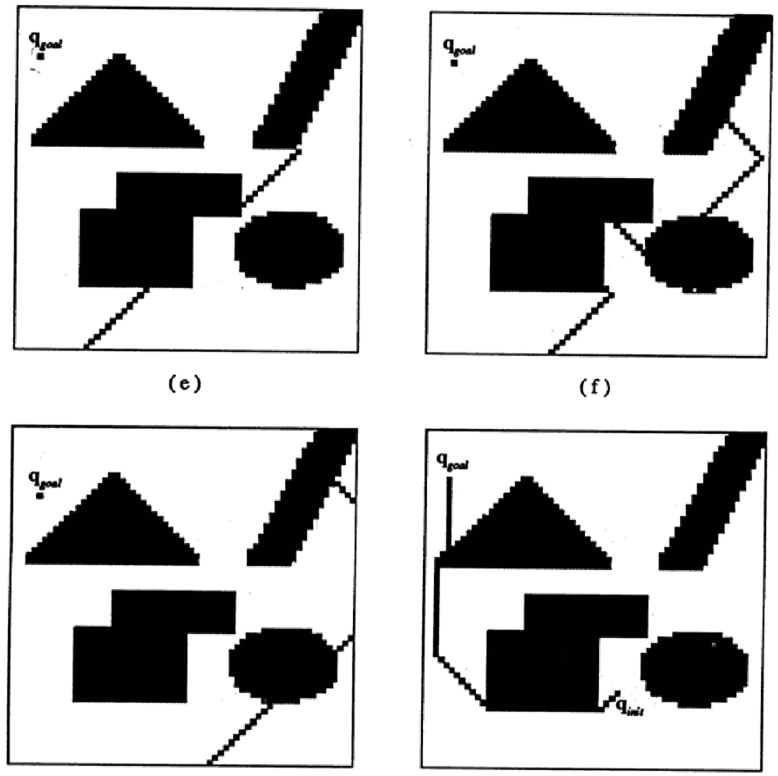

Figure 3.2. This figure is the continuatic of Figure 3.1.

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3) Do a best first search from q_i

Downside of NF1 | Path tends to graze along obs. edges

NF2 : "paths will go along the middle"

1) Compute L' pot. field starting from

obs boundaries

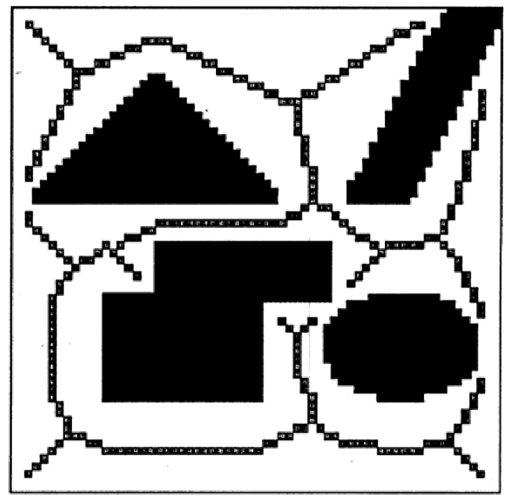

Figure 4. This figure shows the skeleton computed in the same two-dimensional space as in Figure 3 (with the parameter α equal to 4).

of Q — call it $\mathbf{q}$ — is removed from Q; every m-neighbor[10] $\mathbf{q}'$ of $\mathbf{q}$ in $\mathcal{S}$ whose potential has not been computed yet receives a potential value equal to $\mathbf{U}(\mathbf{q}) + 1$ and is inserted in Q. The algorithm terminates when Q is empty, i.e. when all the configurations in $\mathcal{S}$ accessible from $\mathbf{q}_{goal}$ have been given a potential value. A formal expression of the algorithm

2) Connect q_g to skeleton S following the L_1 dist. pot. field. Assign $q_g = 0$ pot. and propagate this pot. only along S

q_g

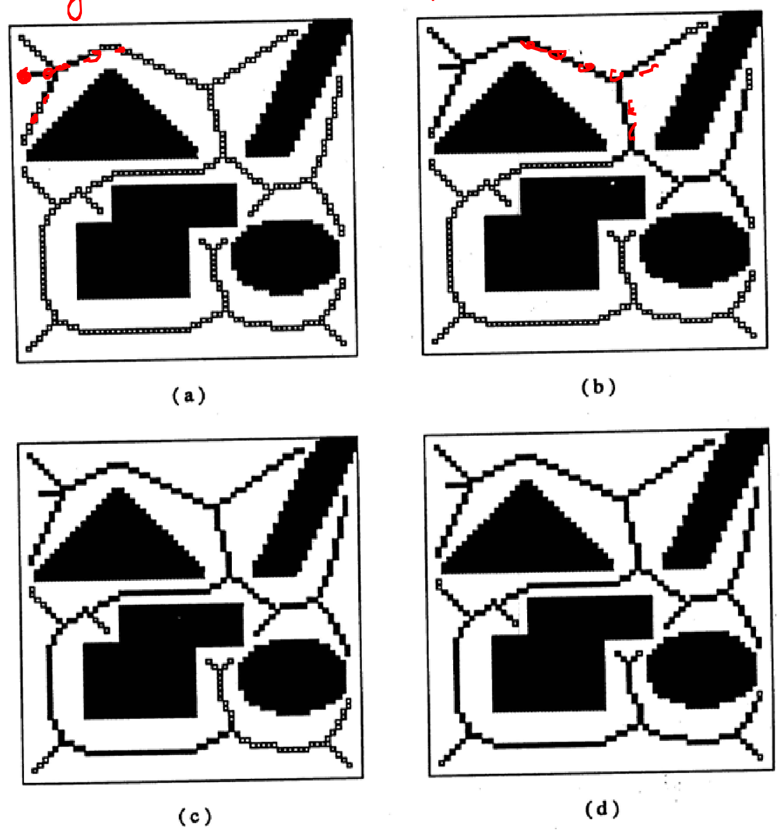

Figure 5. This figure illustrates four stages of the wavefront expansion carried
... procedure NF2 in the skeleton of Figure 4. The skeleton elements

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3) expand L' pot. from skeleton pot. values outward.

DONE

search from q_i using Best First.

~~NF~~ **Numer. Nav.** functions avoid local minima due to multiple obstacles in workspace.

But local minima due to multiple control pts defined on robot body are still there.

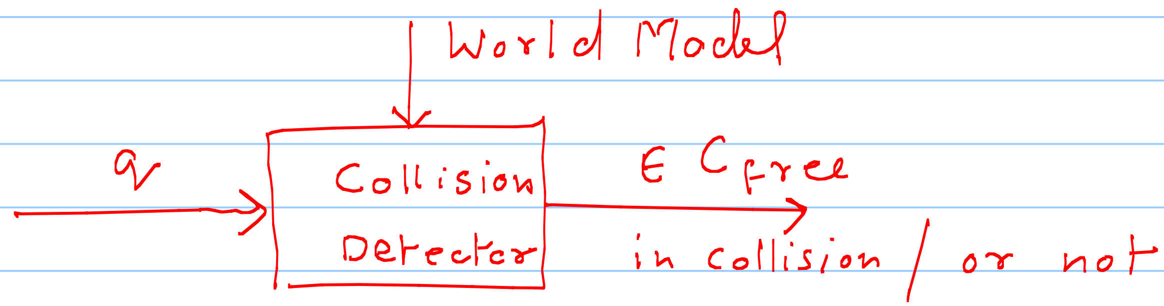
Early planners for medium sized 3 - 8 dim. of C-space used NFs with local minima escape techniques.

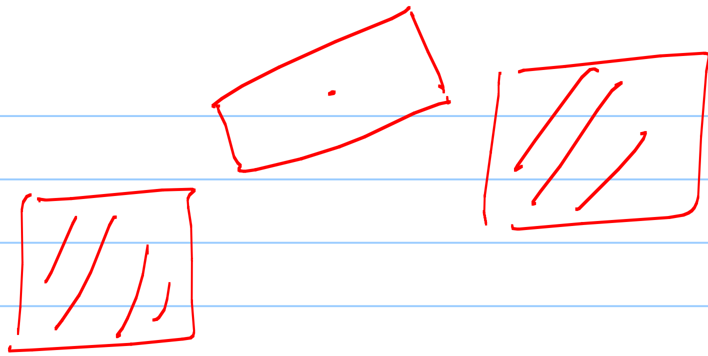
4) Sampling Based approaches

(Choset Book)

Recall: Determining C-space obs.

Boundaries is quite complex even for 2D poly. with rot (x, y, θ)





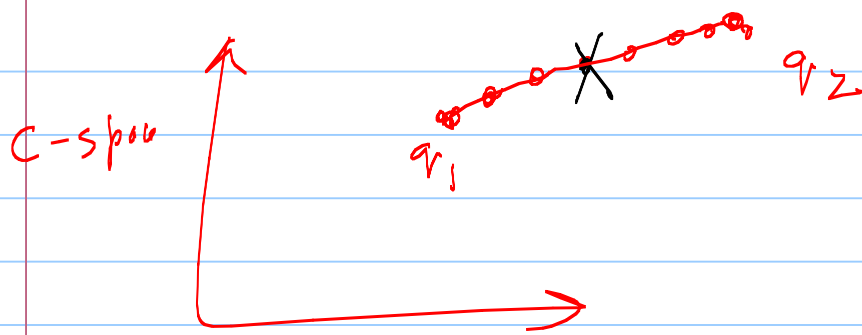
Collision det. is a key computation.
efficiency is critical

World Model

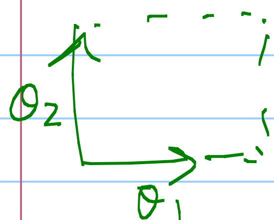
② q_1, q_2 → Local Path ~~Planner~~ LPP → yes/no if q_1 + q_2 are connected by the LPP

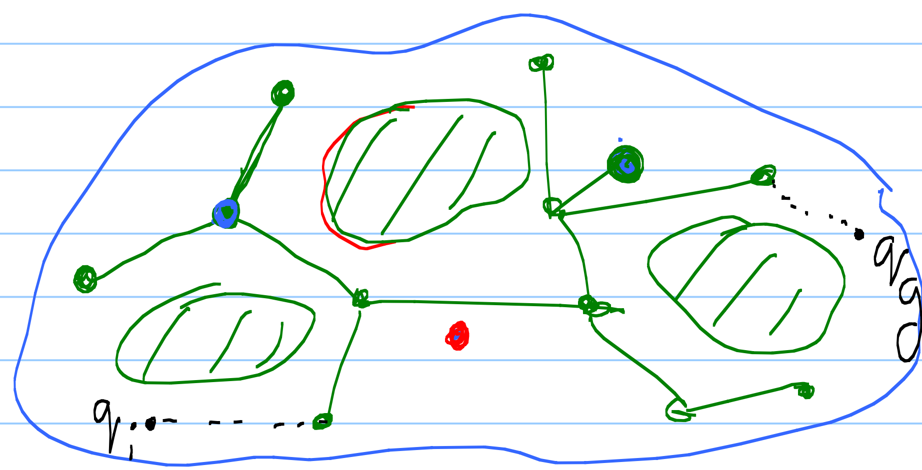
LPP $\rightarrow$ 1) quick

2) Deterministic



3) Use a sampling scheme in c-space





free samples

$\downarrow$

vertices in a graph

Roadmap

$$R = (V, E)$$

V : samples that $\in \mathcal{C}_{free}$

E : $v_1 v_2$: if LPP connects $v_1 v_2$

4) Metric in C-space : Can use any of the metrics we have looked at in prev. lectures

Probabilistic Road·map (PRM)

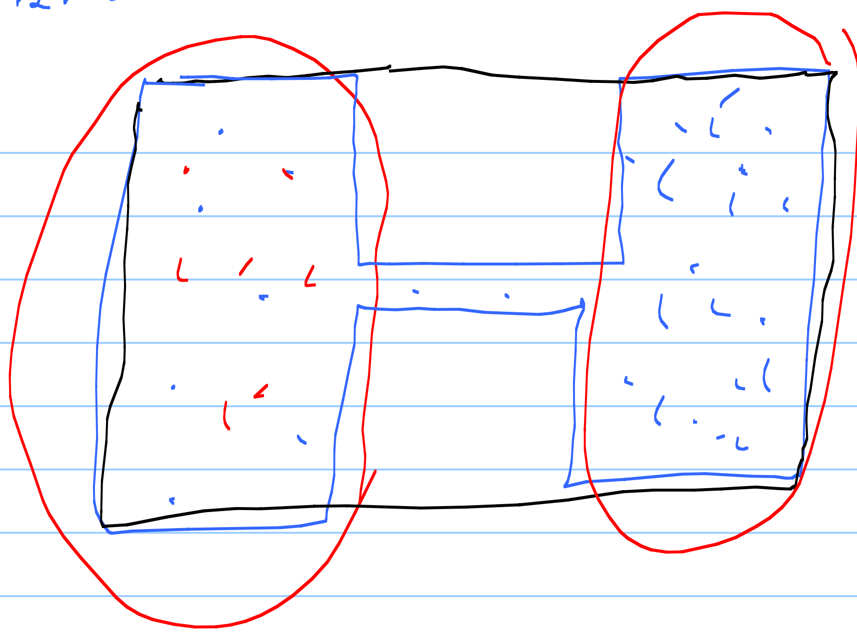
1) multi querry → pre proc : Build the Roadmap
→ query phase : connect q_i, q_g to roadmp

2) single "

Key Problem : "Narrow passage problem"

⟹ if no path exists, planner does not

know when to stop. The longer it runs,



higher prob. that a path will be found if ∃ exists one.

Next class: we will look at analy. expr. for this prob.