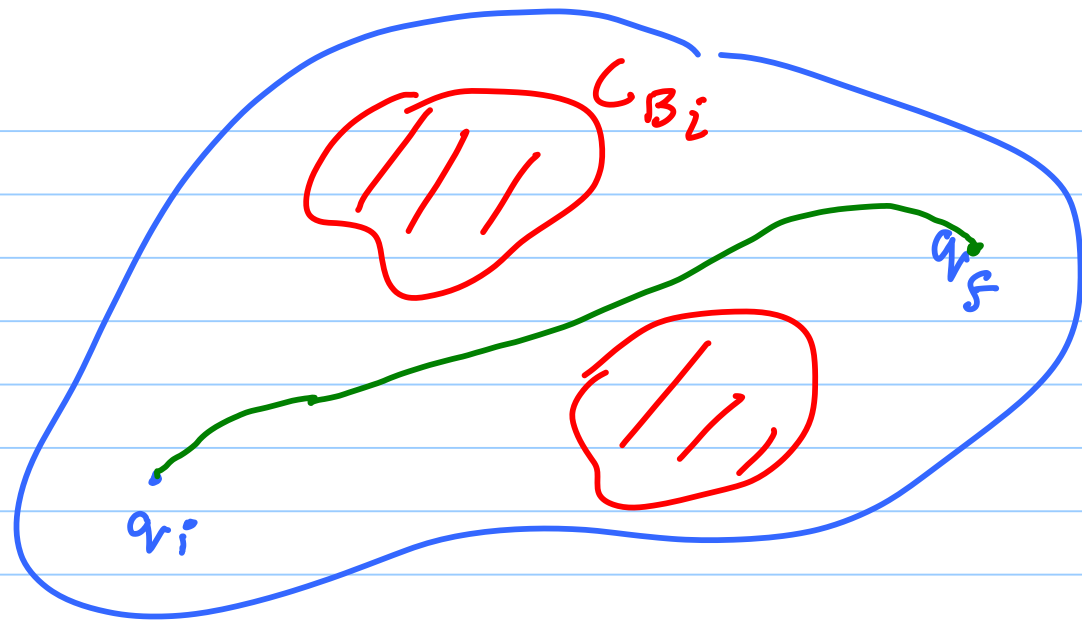
Note Title 2/7/2012

Lecture 10

We have posed the path planng problem for a robot $\mathcal{A}$ moving amongst obstacles (known) $\mathcal{B}_i$ as that of connecty start config q_i to final config q_f via a path $\tau \in C_{free}$.



1) Dimensionality of C space can be high

2) Determining C_{B_i} is quite computationally complex

polygon $\xrightarrow{\text{translational only}}$ C_{obs} are polygons

$\xrightarrow[\text{rotation}]{\text{allow}}$ C_{obs} $\longrightarrow$ given q:

$q \in C_{obs}$ or not

We will leave C_{obs} complexity,

and for now focus on <u>alg.</u> to

get τ, given C_{obs},

Alg. for path planning: will it find a path, if there exists one?

a) heuristic or adhoc: are not able to say in a definite manner if a path exists or not in All cases "incomplete"

1) Complete Alg. : if a solution (or a path) exists, the alg. will find it in a finite amount of time, and returns no solution exists otherwise.

2) <u>Resolution Complete</u> : if a soln. exists within a certain resolution, it

will find it and return no, otherwise

soln. exists with that resolution

Probabilistic Completeness

3) "Sampling the C-space"

will find a solution with prob. $\to 1$

if a soln. exists.

Four Broad Categories of Alg:

1) Roadmap based approaches
2) Cell Decomposition "
3) Potential Based approaches
4) Sampling based approaches.

1) Criticality based   2) Sampling based

We will take a quick look at each of these approaches in specific situations to get a flavour of the approach/alg.

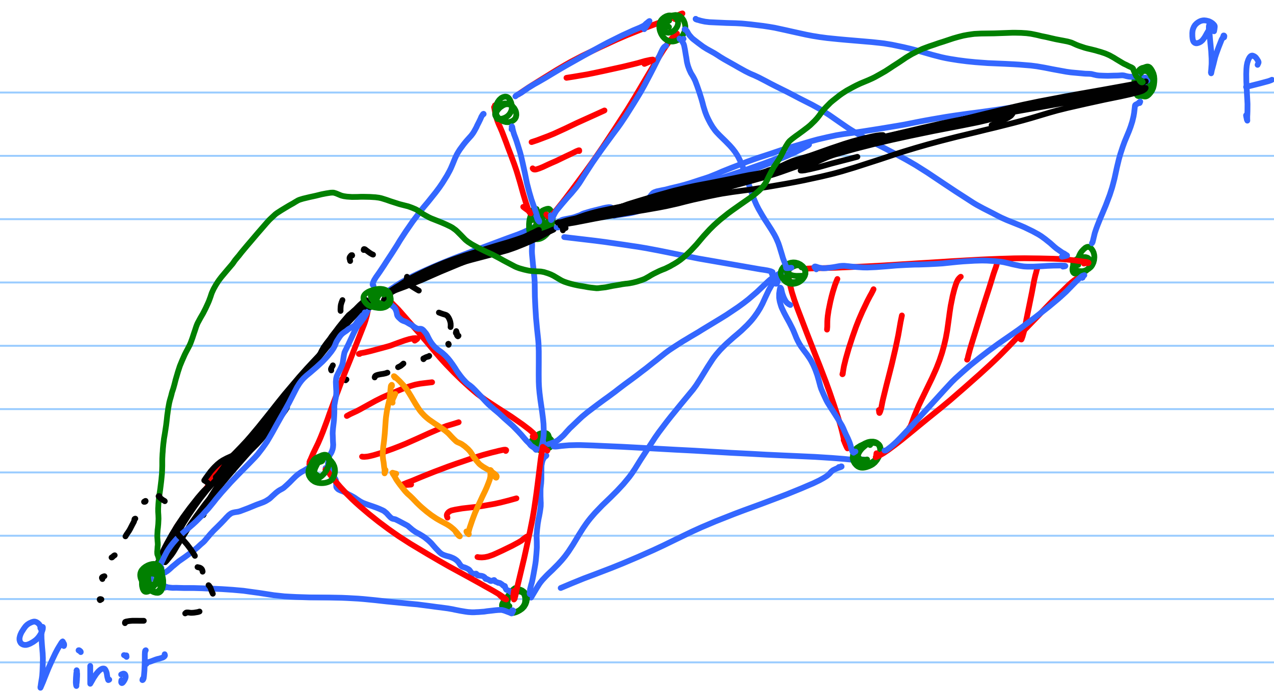
1) Roadmap based approaches

idea is to capture the connectivity of $\mathcal{C}_{free}$ in the form of a "network" of 1-dimensional curves that lie in $\mathcal{C}_{free}$. This network is

Called the roadmap R and it provides a set of "standardized" paths. Path planning is reduced to connecting "q_i" and "q_f" respectively to R.

<u>Example:</u> 2D Case, polygon robot
" obs.

Translation only



"Visibility Graph" : $G(V, E) = R$

$V = \{q_i, q_f, \text{obstacle vertices}\}$

$$E = \{(v_i, v_j) : \overrightarrow{v_i\, v_j} \cap \mathrm{Int}(CB_i) = \phi\}$$

|| reduced Path Planning to a graph search on G. $\longrightarrow$ Dijkstra's shortest path alg.

A* algorithm.

appendix.

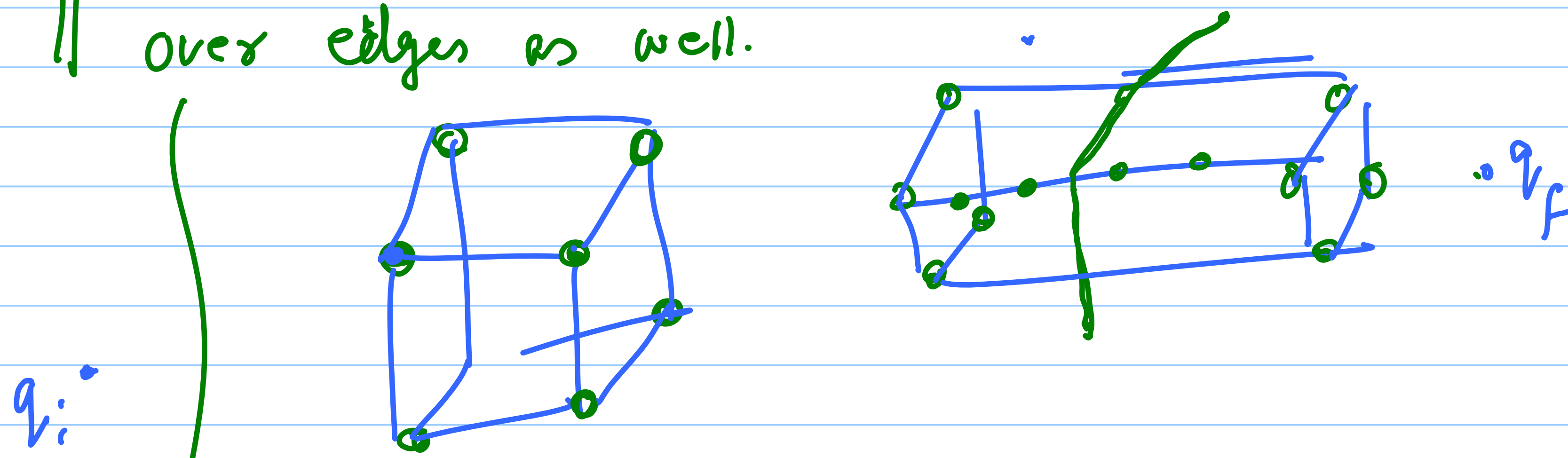
(Collision free)

shortest path from q_i to q_f

complete algorithm.

extension to 3D: translating polyhedra

shortest path can pass over edges as well.



just searching for the vertices is not enough!!

John Canny's paper "shortest path in finding 3D" is NP-hard.

In 2D: Voronoi diagram (obstacles as sites) serves as a roadmap.

1-dim entity

$$P : C_{free} \to Vor(C_{free})$$

is a continuous mapping.

"retraction"

E:

Let X be a topological space.

Let $Y \subset X$.

A map: $f : X \to Y$ is called

a retraction, if f is continuous,

and restriction of f to Y is

Y itself. $\rho(Y) = Y$. We

are interested in retractions that

are connectivity preserving.

Hard part: || how to come up with it?

"Hierarchical Generalized Voronoi Diagrams"

~~5th~~

3) Silouhette Method : very general

"singly" 2^d

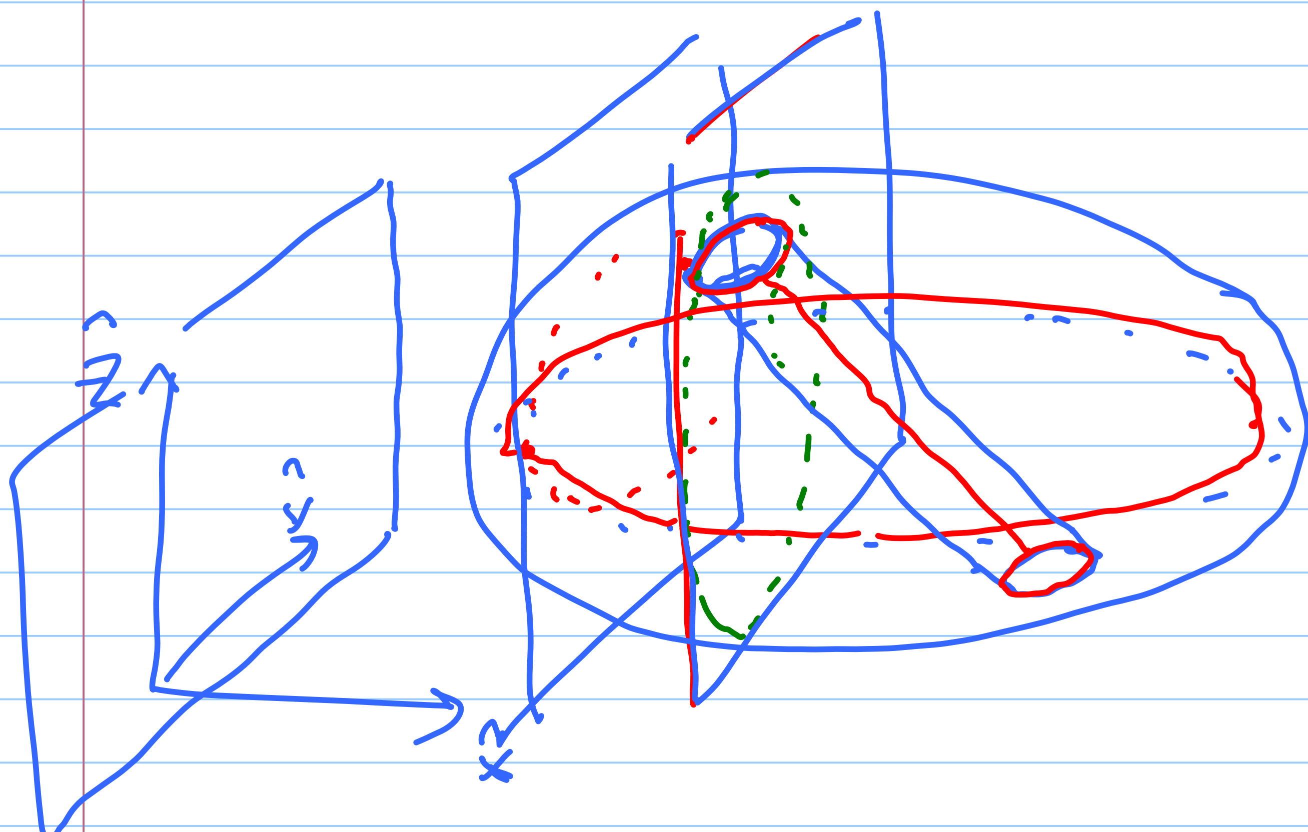
approach : exponential in

the dim. of C-space. Complete

algorithms.

"obstacles / robot surfaces" are semi-algeb. sets.

Conceptual illustration



Retraction like Methods: "freeway Method"

|| polygon amongst polygonal obs.

(limited rotation)

we will skip it.