Autonomous Mobile Robotics

Ray Casting & Ray tracing

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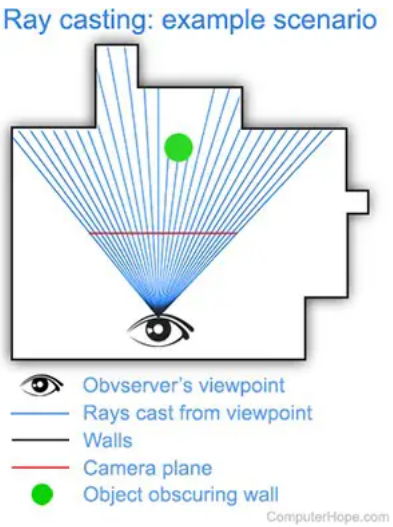
Ray casting & Ray tracing

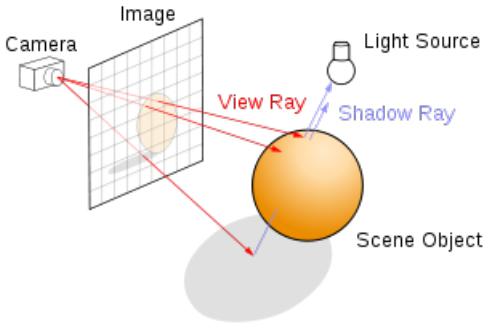
- What is a ray?
- What are those ray techniques?
- What are the differences between them?
- Are they actually used in robotics?

Ray casting & Ray tracing

- Not necesasrily a light ray. For instance, sound-ray approaches to ray tracing.
- Ray tracing and ray casting are methods of building the scene based on the intersection of rays with scene objects.
- Ray casting is easy and simple algorithm only searching for one intersection. Ray tracing algorithms are capable of recursively tracing reflexions. Both algorithms used to visualize an object calculating a color of each pixel during projection on the camera plane.
- They are both used in robotics in various ways.

Ray casting & Ray tracing





Ray casting and Tracking[1]

Having global path planning problem one can use ray casting as an efficient way of finding a most optimal path.

However, this path does not seem optimal enough?

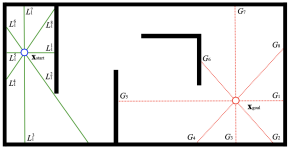


Figure: Initialization

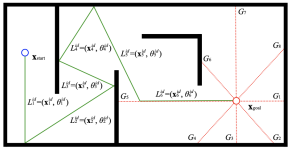


Figure: Expansion

[1] Kim, Lee, and Hong 2018.

Ray casting and Tracking

That is why we need one more algorithm step — trimming.

And finally trimming interpolation.

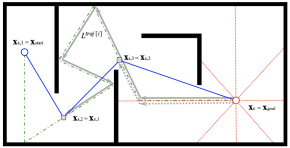


Figure: Trimming

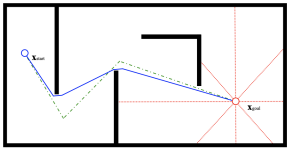


Figure: Trimming interpolation

Ray casting and Tracking

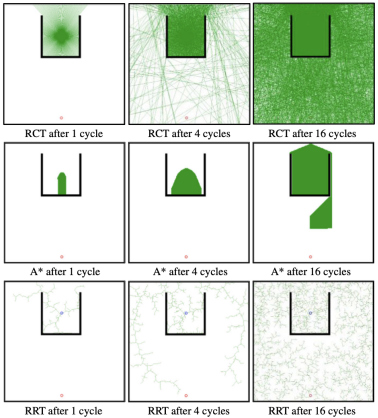


Figure: Comparison of *RCT*, *A** and *RRT*

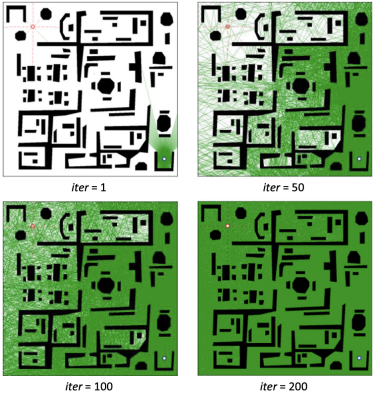
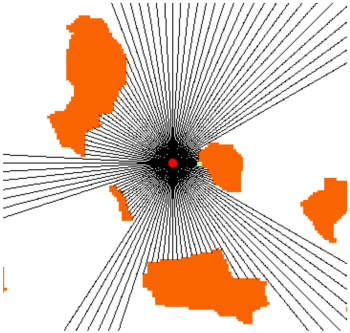


Figure: RCT in action example

Collision Avoidance in Sailing Robots[2]

Sailing robots typically equipped with a small embedded computer require computationally efficient, simple and at the same time comprehensive solution to collision avoidance.

Figure: Ray casting example



[2] Sauzé and Neal 2010.

Collision Avoidance in Sailing Robots

We should consider:

- Coastline data
- Ship locations
- Weather information
- Other hazards

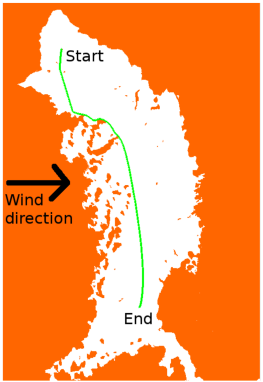


Figure: The course sailed by the robot in Strangford Lough.

Collision Avoidance in Sailing Robots

- We can vary scanning angle
  - Too wide angle more computationally heavy and makes it difficult to analyse obstacles on heading direction.
  - Too narrow angle ignores obstacles which we may face after changing heading direction
- It seems that optimal path is the closest free beam to the target (more on that in original paper)

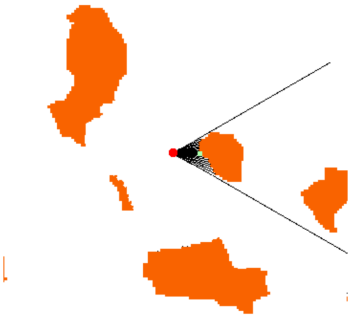


Figure: 60 degree wide beam.

RT2 — Real-time ray-tracing[3]

Imagine having a fleet of AUVs (Autonomous Underwater Vehicles) each equipped with on-board acoustic modem. How to localize them?

Acoustic localization:

- Several vehicles are on the surface and GPS-linked
- Underwater vehicles build a localization net
- Acoustic localization algorithms allow to localize a vehicle w.r.t. other vehicles, for instance, GPS-linked.

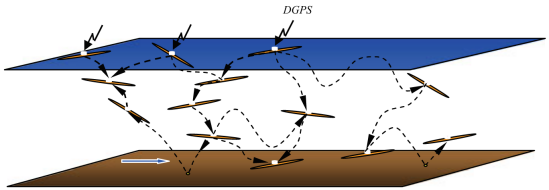


Figure: Acoustic localization concept

[3] Casalino et al. 2011.

RT2 — Real-time ray-tracing

- Assuming we know sound velocity profile as the function of depth a-priori, we can build look-up tables and sound-rays tracing in such a way that units will be able to localize themselves.
- Simulation show that perfectly knowing sound profile allows us to have an accuracy with errors of around few centemeters. Moreover, even under uncertainties algorithm has proven working well.

Coverage Path Planning[4]

Having region of interest which should be inspected, we can use ray tracing to generate volumetric representation of the covered regions.

Moreover, ray tracing is done via the ultrasonic testing of the environment.

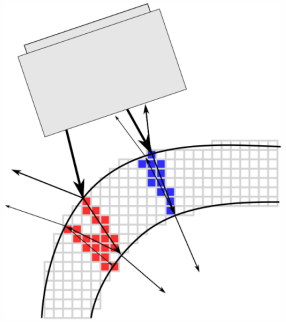


Figure: UT example

[4] Felsner, Schlachter, and Zambal 2021.

Audio position estimation[5]

A robot can detect objects in the blind region of its laser range if those objects emit sound.

Having information about acoustic reflection and estimated via ray tracing directions of arrival of the sound we can detect objects that are not visible, but can be heard.

[5] Even et al. 2014.

References I

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