Convex Hull Algorithms for Collision Detection in Self Driving Cars

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Project Description:

Collision detection is the computational problem of detecting the intersection of two or more objects. While collision detection is most often associated with its use in video games and other physical simulations, it also has applications in robotics. In addition to determining whether two objects have collided, collision detection systems may also calculate time of impact (TOI), and report a contact manifold (the set of intersecting points). Collision response deals with simulating what happens when a collision is detected (see physics engine, ragdoll physics). Solving collision detection problems requires extensive use of concepts from linear algebra and computational geometry.

Computing a convex hull (or just "hull") is one of the first sophisticated geometry algorithms, and there are many variations of it. The most common form of this algorithm involves determining the smallest convex set (called the "convex hull") containing a discrete set of points. This algorithm also applies to a polygon, or just any set of line segments, whose hull is the same as the hull of its vertex point set. There are numerous applications for convex hulls: collision avoidance, hidden object determination, and shape analysis to name a few. And they are a minimal linear bounding container.

Algorithms to be implemented:

- **Gift Wrapping:**
  The idea of Jarvis's Algorithm is simple - We start from the leftmost point (or point with minimum x coordinate value) and we keep wrapping points in counterclockwise direction.
- **Graham Scan:**
  The algorithm finds all vertices of the convex hull ordered along its boundary. It uses a stack to detect and remove concavities in the boundary efficiently.
- **Monotone chain:**
  It is an alternative to the Graham scan that uses a linear lexicographic sort of the point set by the x and y-coordinates. This is an advantage if this ordering is already known for a set, which is sometimes the case. But even if sorting is required, this is a faster sort than the angular Graham-scan sort with its more complicated comparison function. The "Monotone Chain" algorithm computes the upper and lower hulls of a monotone chain of points, which is why we refer to it as the "Monotone Chain" algorithm.

Planned Configuration Details:

- **Hardware Specifications**:
  - MacBook Air 2019, 8 Gb RAM, Intel i5 Dual Core Processor
- **Software Specifications**:
  - Operating system: MacOS, Programming language: Python 3.x