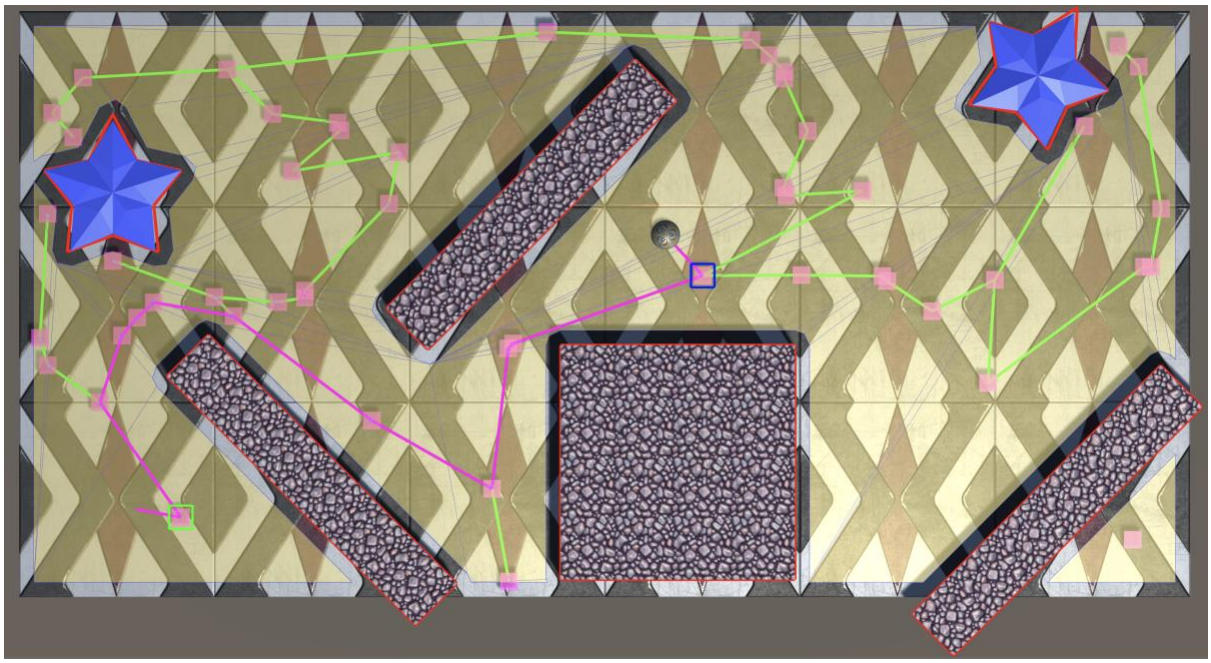
Homework 4: NavMesh Generation

In this homework you will be implementing an algorithm for creating NavMeshes.

A **navigation mesh** (or **navmesh**) is a method of creating a discretized space representation of a navigable area. A navigation mesh is a set of convex polygons overlaid on an environment such that the area within each polygon is guaranteed to be obstacle-free. The variable size and dimensions of navmesh polygons provide efficient representation of space as compared to the uniform structure of a grid lattice. It also captures more usable information about the environment than a path network alone. The convexity of the polygons is important because an agent within the area of a polygon can move to any other point within without crossing a boundary (e.g. colliding).



When two navmesh convex polygons are adjacent to each other (i.e., they share an edge), that edge can be thought of as a "portal"—an invisible door—from one safe navigation region to another. Connecting adjacent convex polygons into a network of safe paths results in a path graph through which an agent can travel between connected navigable locations.

There are various ways to convert a navmesh into a graph with path locations (e.g. a path network). A popular approach, and one that reduces the number of nodes, is to use the centroid of each navmesh polygon.

In this assignment, you will write the code to generate a navmesh for an arbitrary environment as well as an accompanying path network from the navmesh.

There are three main challenges of the assignment:

1. Form adjacent triangles that cover all the navigable space
2. Merge triangles into larger, more efficient polygons that are also convex

3. Create a path network from the navmesh

What you need to know

Please consult **homework 1** for background on the Game Engine. In addition to the information about the game engine provided there, the following elements will be used.

CreateNavMesh

This file contains a Create() method that you must implement. Additionally, be sure to change the student name string. Considerable scaffolding and comments are provided, which will aid in development of your solution.

Create(): Creates a navmesh and pathNetwork (associated with navmesh)
canvasOrigin: bottom left corner of navigable region in world coordinates
canvasWidth: width of navigable region in world dimensions
canvasHeight: height of navigable region in world dimensions obstacles: a list of Polygons that are obstacles in the scene
agentRadius: the radius of the agent
origTriangles: out param of the triangles that are used for navmesh generation. These triangles are passed out for visualization.
navmeshPolygons: out param of the convex polygons of the navmesh (list). These polys are passed out for visualization
pathNodes: out param: a list of graph nodes, centered on each navmeshPolygon
pathEdges: out param: graph adjacency list for each graph node. cooresponding index of *pathNodes* to match node with its edge list. All nodes must have an edge list (no null list) entries in each edge list are indices into pathNodes

The scaffolding and inline comments of CreateNavMesh.Create() gives specific guidance and recommendations on other classes and methods to use. However, a brief summary of other classes and relevant methods is provided.

Polygon

A Polygon is a set of points that form a closed polygon, with the last point connecting with the first one.

Relevant member functions:

- GetPoints(): returns a list of all corners in the polygon. A point is a Vector2 of the form (x, y).
- IsPointAVertex(Vector2): returns True if a point is one of the vertices of the poly
- IsPointInPolygon(point): returns True if a point (x, y) is inside the obstacle.
- GetCentroid(): returns the centroid of this polygon
- IsClockwise(): returns true if the polygon is clockwise
- IsConvex(): returns true if polygon is convex
- Reverse(): reverses the points order of this polygon (e.g clockwise to anti-clockwise)

- SetPoints(Vector2[] newPoints) : Sets the points of the polygons to the array of points passed as newPoints.

Miscellaneous utility functions

Miscellaneous utility functions are found in Utils.cs.

Relevant member functions:

- IsCollinear(various args) – Check for collinearity of vertices provided (or part of a polygon)
- IsLineInPolygons(Vector2 A, Vector2 B, List<Polygon> polys) – Check if a line is in any of a list of polygons. That is, an edge of at least one of the polygons
- IsLineCoincidentWithLineInPolys(Vector2 A, Vector2 B, List<Polygon> polys) – Check if a line is parallel and touching (with overlap) with at least one edge of a list of polys
- ConvexIntersection(Polygon, List<Polygon>) – Tests for intersection, but only effective with convex polygons
- IntersectsWithComplexPolys(Vector2, Vector2, List<Polygon>) – Tests for intersection of a line with a list of polygons. This test works with complex polygons without holes, and is an approximate method. It's expensive computationally.
- IsConvex(points): returns true if all the angles made up by a list of points are convex. Points is an array of points(Vector2).The list must contain at least three points.
- MergePolygons(Polygon, Polygon, Vector2, Vector2): returns a new Polygon merged across common edge defined by two provided points

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Instructions

Download the project from Github and open in Unity. Open the Navmesh scene and the CreateNavMesh.cs file. Follow the comments in CreateNavMesh.Create() to build a working navmesh generator. **Don't forget to set the student name to your name.**

Grading

We will grade your solution based generally on three criteria:

- **Coverage:** The navmesh should cover the entire navigable area of the map, no more and no less.

- **Reachability:** The path network should include pathNodes at the centroid of each navmesh polygon and pathEdges should span across portal edges of adjacent navmesh polygons.

- **Mesh optimization:** Your solution should effectively merge navmesh triangles (or more sided polygons) together resulting in a reduction of pathNetwork complexity

Submission

To submit your solution, upload your modified CreateNavMesh.cs (did you remember to change the student name string to your name?). All work should be done within this file. Helper methods within the same file are fine.

You should not modify any other files in the game engine.
DO NOT upload the entire game engine.