DPA*: Dynamically Pruned A* for Re-planning in Navigation Meshes

In simulations and games, AI-controlled agents can use the A* search algorithm on a navigation mesh to plan paths through an environment. When an obstacle is inserted or deleted, the mesh changes and agents should re-plan their paths. We present DPA*, an extension of A* that re-plans an optimal path for an agent based on the old path and the dynamic obstacle. DPA* is fast, memory-friendly, and suitable for real-time crowd simulation.

Path Planning in Navigation Meshes

A navigation mesh subdivides the walkable space of an environment into regions. An agent uses the dual graph of this mesh to plan a path to its goal.

Dynamically Pruned A*

DPA* adds pruning rules to the standard A* search algorithm. These rules are different for each of the four possible re-planning scenarios.

1. Insertion, old path not in R
   The old path [TG] is still optimal. Re-planning is not necessary.

2. Insertion, old path in R
   For any vertex on subpath [BG], we now what its successor will be.

3. Deletion, old path not in R
   If there is a better path than [TG], then it must visit R at least once.

4. Deletion, old path in R
   The old path is obstacle-free, but [AB] no longer exists in the graph.
   As in scenario 3, the new optimal path must visit R at least once.

Dynamic Events

When an obstacle (dis)appears, the navigation mesh and its graph change. The agent’s path may now be invalid, or a better path may have appeared.

When finding a new optimal path, parts of the old path can typically be re-used.

Most re-planning algorithms remember the entire previous search and are too memory-intensive for crowds.

DPA* uses only the old path and its relation to the affected region R. It always computes an optimal path.

Experiments and Results

We have implemented DPA* and tested it on the Explicit Corridor Map (ECM) navigation mesh. Our algorithm is particularly efficient when:

- the graph is large,
- the path is long,
- a dynamic deletion is far away from the agent,
- a dynamic insertion is close to the agent (e.g. the agent can see the new obstacle).

DPA* can be over 60% faster at re-planning than regular A*.

Our crowd simulation software can model tens of thousands of agents in real-time. DPA* enables efficient re-planning in dynamic environments.