A Literature Review of the Use of Databases to Improve the Efficiency of Computations for Sub-Optimal Pathfinding in Video Games

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ACM Reference Format:
Katrina Ziebarth. 2022. A Literature Review of the Use of Databases to Improve the Efficiency of Computations for Sub-Optimal Pathfinding in Video Games. In *Proceedings of ACM Conference (Conference'17).* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

The use of databases to improve the efficiency of pathfinding in video games has implications for the potential complexity of video games. It offers a a way to reduce the cost of pathfinding, freeing resources for the other components of a video game.

Perhaps the most notable work in this field is O'Grady's 2021 dissertation [8].

The need for this research can be seen in O'Grady's observation that "it is not uncommon for business logic of any kind (including video games') to read all data from the database, compute a subset of the data or transformation thereof in an imperative programming language, and then write it back periodically." As O'Grady notes, increasing data locality could potentially allow for much greater efficiency . O'Grady also observes that "DBMSs have decades of development and optimisation under their belt" [8].

This work departs from O'Grady's in its focus on sub-optimal pathfinding. The reason for this is the lack of necessity of optimal paths in video games under most circumstances. As Botea et al. notes, "In games, the optimality of solutions is not seen as a must-have feature. Suboptimal paths that look reasonable to a user are acceptable" [3]. The admission of sub-optimal pathfinding algorithms allows for a wider range of approaches, potentially leading to increased efficiency in the production of reasonable solutions.

2 UTILIZATION OF DATABASES TO IMPROVE EFFICIENCY

Previous work exists concerning the utilization of databases to improve the efficiency of other systems. Bendre et al. explores how a spreadsheet can be unified with a relational database while preserving advantages of both [2].

Conference'17, July 2017, Washington, DC, USA

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/10.1145/nnnnnnn.nnnnnnn

Similarly, in his dissertation, O'Grady explores the implementation in SQL of not only pathfinding, but also of AI and map generation [8]. O'Grady's 2019 work also investigated the implementation of map generation in SQL [7]

3 PATHFINDING IN VIDEO GAMES

A vast amount of relevant work exists in the field of pathfinding in video games. For this reason, this literature review will focus mainly on surveys and overviews of pathfinding in video games, going into greater depth only where necessary.

3.1 Algorithms

Kapi identifies A* as the most prominent algorithm in video game pathfinding [5]. Similarly, Abd Algfoor notes that A* is among the most well-known search algorithms in games and robotics and that it "inspired many modified and improved algorithms" [1]. For these reasons, it is unsurprising that O'Grady's 2021 investigation of pathfinding focuses on A* and variants based on it [8].

3.2 Optimization

Kapi offers an overview of various ways of optimizing pathfinding in video games, including choice of graph representation, modification of heuristic functions, and choice of data structure for implementation [5].

3.3 Sub-Optimal Pathfinding

In regards to sub-optimal pathfinding, Botea et al. identified as promising the idea of "combining compressed path databases with hierarchical abstraction" [3].

3.4 Heuristics

The three heuristics which O'Grady discusses for use with A* are Manhattan distance for Von Neumann neighborhoods and Euclidean distance and Chebyshev distance for Moore neighborhoods [8].

Botea et al. notes that Manhattan distance and Octile distance are "simple, fast to compute, and reasonably accurate on many map topologies" [3].

3.5 Environments

O'Grady's 2019 work uses the OpenRA engine [7], as does his 2021 dissertation [8]. In explaining the reasons for his choice of it for his dissertation, O'Grady gives as advantages that it is open source and under GNU General Public License, has a development community which can be contacted for inquiries, has all core components written in an object-oriented programming language, and has a "clear-cut set of mechanisms" for managing several actors due to its focus on real time strategy games [8].

Video games utilize a range of techniques for terrain discretization, with Nash and Koenig giving examples of games using regular grids, navigation meshes, and circle-based waypoint graphs [6].

Unfortunately, it was not possible to determine whether O'Grady's experiments to measure performance in OpenRA used Von Neumann neighborhoods or Moore neighborhoods. O'Grady discusses both types of neighborhoods and uses in his code the boolean pseudo-function neighboring(a, b) [8]. It seems probable that his goal in doing so was to make the code more general and avoid the need to present separate implementations for the two types of neighborhoods.

3.6 Existing Benchmarks

A number of pathfinding benchmarks drawn from commercial games which utilize 2D grids exist [9]. For 3D voxel grids, a benchmark set from the game Warframe has been made available [4].

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