Fractal Analysis of Stealthy Pathfinding Aesthetics – Summary

Introduction

The paper mathematically proves that a “stealthy” path is aesthetically better than the standard path finding algorithms, but not as aesthetic as an entirely aesthetic path finding algorithm. Aesthetic in this context is a smooth and seemingly natural path. The paper noted that aesthetic algorithms are not always natural, i.e. absolutely aesthetic paths may be paths that a human would not take and are obviously system generated paths, detracting from game realism, hence immersion. The article aimed to show that a “stealthy” path would be a more logical path, but also aesthetic enough to seem natural, balancing the visual and logical elements to pathfinding.

Theory

The paper uses fractal analysis to examine the result of the “stealthy” algorithm as it has been shown to reliably and accurately represent the aesthetic analysis of data. The paper notes that aesthetic analysis has not been applied to pathfinding or artificial intelligence in general, everything in the field is about optimization and efficiency.

The fractal model, $G(P^1|P^0) > 0$, states that fractal analysis of a path, P^1, and a reference path, P^0, results as P^1 being more aesthetically pleasing than reference P^0.

The paper uses a geometric fractal dimension algorithm to accurately calculate the fractal dimension of objects under analysis. A modified version of FracTop, which uses reticular cell counting to reliably calculate the fractal dimensions, is implemented. FracTop requires a 2D PNG image as input to perform its analysis.

The fractal model uses a surface S, comprised of the generated world W, rigid-body obstacles, $\{B^j\}$, and the path P. From this, the fractal beauty of a path is represented by $G(P^1|P^0) = D(P^1) - D(P^0)$ where $D(P)$ is the fractal dimension of path P. This assumes that the world, W, and the start and goal points are the same for P^1 and P^0. As stated above, if $G(P^1|P^0) > 0$, then P^1 has a greater fractal beauty than P^0.

The fractal beauty function, G, is only for determining the fractal beauty and not the actual path. For finding the actual path, A* search is implemented. However, using A* with beautifying heuristics avoids objects such as walls. Stealthy path finding will make use of walls and other objects to avoid detection, etc. The following function is created for producing a stealthy path:

$H(A^{goal}, \gamma) = (1-\gamma).h(A^{goal})$, where γ is the stealth effect and $h(A^{goal})$ is the Manhattan metric. With this following function, there is no relation between the A* heuristic cost and the stealth effect, and the possible stealth effects will either produce a standard, aesthetic or stealthy path. This shows the algorithm is not intrusive to current pathfinding algorithms and can produce the correct result based on the desired path characteristic.

Testing

The paper notes that choosing the stealth effect γ, requires some trial and error testing. The paper uses γ at 10% and γ at 15%. The tests are performed with $G(P^{stealthy}|P^{aesthetic})$ vs $G(P^{stealthy}, P^{standard})$. The results show that $P^{stealthy}$is indeed less aesthetic as $P^{aesthetic}$, but more aesthetic that $P^{standard}$. This was the desired result, a compromise between realism, human movement and the beauty of the path. These results were consistent with a low standard deviation. Tests between stealthy paths of different stealth effects, γ^1 and γ^2, resulted in a clear, significant difference. This proves that the algorithm does successfully implement the correct stealth effect.

Conclusion

The paper concludes stealth paths have unique aesthetic values. This proves that stealth paths may provide a significant difference in game realism and immersion. This is an important conclusion, as there are many other implementations for this kind of logic. An example is navigation pathfinding. Sometimes the quickest and quietest route may not be the safest, deterring users from using the navigation application as it is not a desirable route.

The paper finally concludes that the generated world W alters the degree to which the stealth effect changes the world.

References

1. Ron Coleman, “Fractal Analysis of Stealthy Pathfinding Aesthetics,” International Journal of Computer Games Technology, vol. 2009, Article ID 670459, 7 pages, 2009. doi:10.1155/2009/670459