Minecraft Stronghold Finding Mathematics

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1 Introduction

Minecraft Stronghold finding system is intriguing from a mathematical perspective. Using trigonometry and analytic geometry, for example, we can create algorithms to help us to find the structure with some precision without using much Minecraft game resources and saving time, mainly for speedrunners. This document aims to discourse about the math solutions to the presented problem.

2 Stronghold Finding System

In Minecraft, there is a unique system to beat the game, the player needs to use an item named "Ender Eye" that shows the way to the structure named "Stronghold" (hidden in the underground), in this place, there is an portal that send the player to another dimension, where it needs to slay the "Ender Dragon", beating the game. The "Ender Eye" is a kind of a compass, that shows the direction to the "Stronghold", when the player uses it, it flies up in that direction, then stops and fall (it has a 0.2 probability of breaking in this process, not been able to be used anymore). So, the player goes in that direction until it thinks it's a good time to throw another one, that will point to the direction of the place again. If the player throws the item nearby the "Stronghold", the "Ender Eye" flies down, informing that the structure is close, so the player can dig down and find it.

With that system in mind, we can use Math and Programming to find a good way to do this process with the least amount of "Ender Eyes" throws, saving time and in-game resources.

3 Intersection of Two Lines

One of the methods to find an "Stronghold" is using Analytic Geometry, more specifically the concept of intersection between two lines. In this context, we can use a program to calculate the point of intersection of two lines, given two points and two directions (those directions are angles in the Minecraft Cartesian plane), thus minimizing the "Ender Eye" usage. So, we'd have the exact position of the "Stronghold".

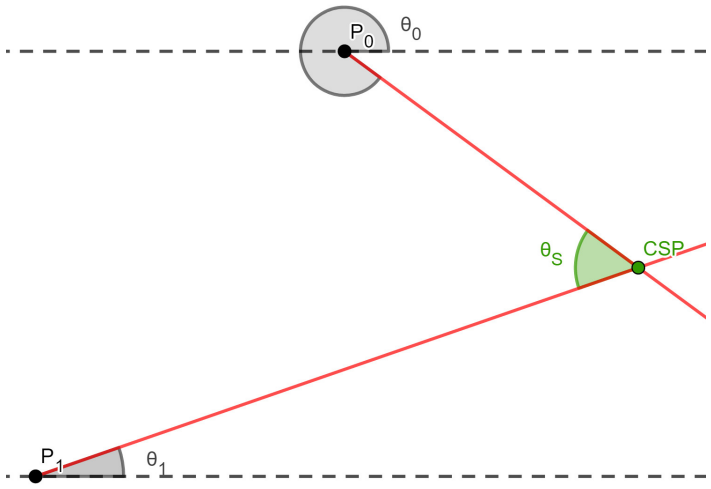

Figure 1: Intersection between two lines.

4 Minecraft Angle Precision

Minecraft angles are accurate to two decimal places only, so when calculating the "Stronghold" position, we have some uncertainty in measuring the exact angle, then there will be an uncertainty area around the calculated "Stronghold" position (CSP), where the true "Stronghold" position (TSP) is, due to that uncertainty.

Minecraft angles measurement has an uncertainty of ± 0.005, assuming values with three or more decimal places are rounded to the nearest two decimal places value, which creates the uncertainty area, that is very small if the angles (θ_S) is big, causing the player to throw an "Ender Eye" just to be sure where the structure is, or to have more precision. Having in mind

that the closer the player is from the "Stronghold" more precise will this method be.

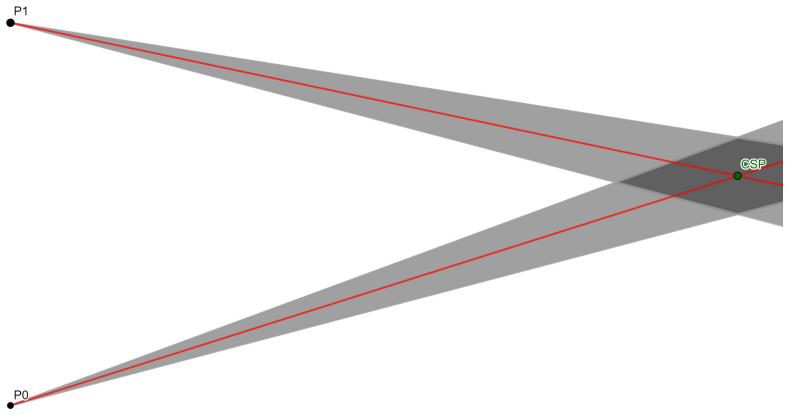

Figure 2: Uncertainty area around the CSP with a big angle θ_S.

But if θ_S is small, accuracy is decreased, and the uncertainty area is big. Assuming that the player will walk closely to the first line calculated at the first "Ender Eye" throw, it is reasonable to state that the value of θ_S is small, unless the player increase this difference, on purpose, to increase the accuracy of this calculation method.

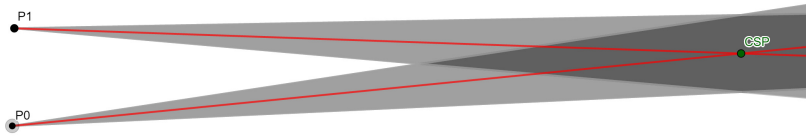

Figure 3: Uncertainty area around the CSP with a small angle θ_S.

5 TSP probabilities

Assuming that all angle's values are rounded to a number with to decimal places, we can conclude that given a certain angle θ, all values in the interval (θ - 0.005, θ + 0.005) would be informed to the player as this angle θ, so there is no way to tell which is the true angle that points to the "Stronghold" ("Stronghold Angle"). With that in mind, we can claim that the probability of the true "Stronghold Angle" be any of the values in that interval is the same. So all angles in the interval are equally likely to be the correct one. It implies that all points in the uncertainty area are equally likely to be the TSP, since the chance of an given point to be the TSP is the probability of the angle θ_0 being the true "Stronghold Angle" in the point P_0 multiplied by the probability of the angle θ_1 being the true "Stronghold Angle" in the point P_1, so, since every angle has the same chance of being the right one, all points have the same chance to be the TSP.

So, the only way to minimize the uncertainty area is making θ_S bigger and getting closer to the "Stronghold". And now we can calculate a good way to optimize this strategy.

6 Optimizing the Strategy

First, we will assume the following:

- Since the player has a higher probability of being closer to the origin of Minecraft's map (0,0) during a speedrun, we'll assume that it will look for a "Stronghold" in the first circular crown of "Stronghold" generation which is 1408-2688 blocks away from origin (Figure 4). It is important to mention that in the first circular crown there is three "Strongholds" symmetrically located, all 120º away from each other (measured from the origin).

- Since the player can be in any place inside that first circle of "Stronghold" generation, we'll calculate the optimized strategy for a distance of 2700 blocks away from the Stronghold, which is the worst scenario, according to the first assumption.

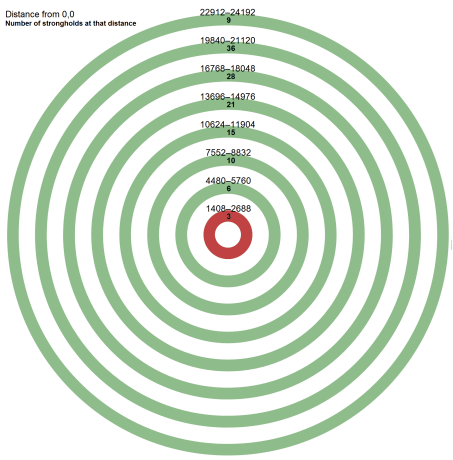

Figure 4: Best positions for each distance to throw the second "Ender Eye".

To find the "Stronghold", we can use only two or three "Ender Eyes". In the first case, using only two, we need a one block precision, since we need to know exactly where it is. Using three, we need a precision of, at least, 11 blocks radius, because, throwing the "Ender Eye" at the CSP, we can guarantee that the "Ender Eye" will fly down, stopping at the TSP, showing where it is (since "Ender Eye" flies down when it is 11 meters from the TSP).

In order to minimize the amount of distance travelled, an algorithm was used to calculate the best positions to throw the second "Ender Eye" to get an 11 blocks radius precision around the CSP (assuming the first launch made at the origin [worst scenario]), granting that throwing a third "Ender Eye" at the CSP, the player will discover the TSP, as mentioned before.

With the graphic (Figure 5), we can conclude that, in the worst scenario, right when the player enters the circular crown (1400 blocks away from origin), where the "Stronghold" can be generated, it only need to move, approximately, 42 blocks perpendicularly to the first direction (the black line) to throw the second "Ender Eye" and get sufficient precision to find the TSP using only three Ender Eye throws. Since we calculated for the worst scenario, we can conclude that moving 42 blocks away from the black line (first direction) the player is granted to have enough precision to find the TSP wherever it is. And, knowing that the closer the first throw is made, closer the blue points will be to the black line, we can conclude that

the maximum distance from the black line the player will have to walk is 42 blocks, which is a little amount. [Melhorar]

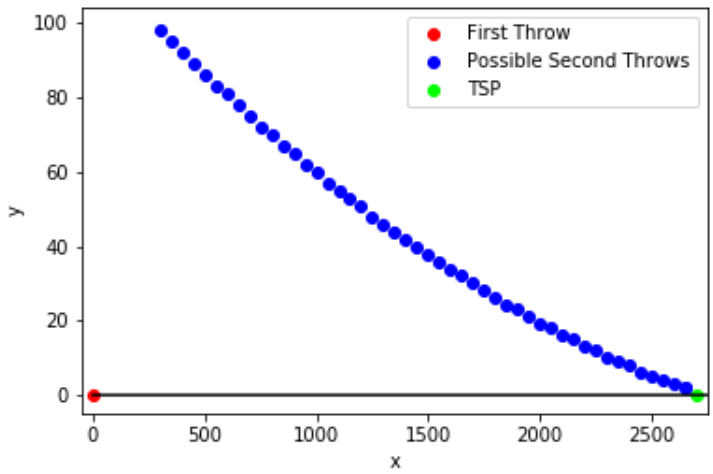

Figure 5: Best position, for each distance, to throw the second "Ender Eye".