Journal of Interdisciplinary Science Topics

Lumberjacking Minecraft Style

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17/03/2013

Abstract
This paper seeks to prove or disprove an element from the videogame Minecraft: is it possible to knock down a tree by punching it? The model used showed that the tensile strength of an oak tree was far too great for it to be plausible for this to happen. However, on further investigation it was found that the model was flawed and an improved model was needed before a definite conclusion could be made.

Introduction
Minecraft is a popular computer game that first became available in 2009. Since the beginning, the general premise of the game was to collect materials and build with them. This article focuses on one of the earliest challenges a player faces: obtaining wood by punching blocks from trees.

Assumptions
Most importantly we will assume that it is humanly possible to punch with a constant force indefinitely, without sustaining any pain or damage to the fist. In addition to this we will assume that the force exerted by the punch is perfectly transferred to the tree with no dissipation.

We will use the model of a Minecraft tree in that it has a perfectly square trunk that is 1 by 1 metre wide and more than a metre tall. Also we will assume that the tree is symmetrical so the centre of mass would run directly through the centre of the tree.

In the game, a block of the tree a meter cubed is knocked from the tree by punching it for 3 seconds[1]. However, to make it more theoretically possible we will instead calculate how much it is possible to compress a small section of the tree by punching it, and if this is sufficient to cause the tree to topple.

The force that we will model will therefore be a blunt force rather than a chopping force so that the trunk is compressed rather than chunks being removed from it. In addition, rather than just hitting the tree randomly, we will model a situation where the area of the fist that strikes the tree is 10cm by 5cm and it repeatedly hits 10 times in a horizontal line so that one side is struck all the way across.

Calculation of Maximum Compression
We can calculate how much it is possible to compress the tree using the following equation for Young's modulus, γ [2]:

$$\gamma = \frac{F/A}{\Delta L/L}$$

Equation 1

Where *F* is the force of the punch, *A* is the surface area that the fist hits, *ΔL* is the change in depth of the tree when struck, and *L* is the depth of the tree before each impact. Therefore, this means that after each punch the magnitude of *L* will change. Using this equation assumes that the section of tree directly surrounding the area struck exerts no frictional force on it, and in effect it is torn from the rest of the tree.

This equation must therefore be rearranged in order to isolate *ΔL*:

$$\Delta L = \frac{FL}{A\gamma}$$

Equation 2

As already mentioned, the area struck is 5 by 10 cm, and the depth is 1m. We will use the force of the punch of the boxer Ricky Hatton, this being measured to be roughly 3922.4N[3]. One of the tree types in Minecraft is oak, we will therefore use the Young's modulus of oak, which is roughly 11GPa[4]. For the first strike this gives:

$$\Delta L = \frac{3922.4 \cdot 1}{(0.1 \cdot 0.05) \cdot 11 \times 10^9} = 7.13 \times 10^{-5} m$$

As is probably expected, each punch compresses the tree a fractional amount; however, even if extremely gradual, it does do so. After 5,000 punches in each location, making a total of 50,000, the tree would be only have compressed into a space roughly 1.0 by 0.7 metres (See Appendix 1 for calculations).

Calculation of Stress on Tree

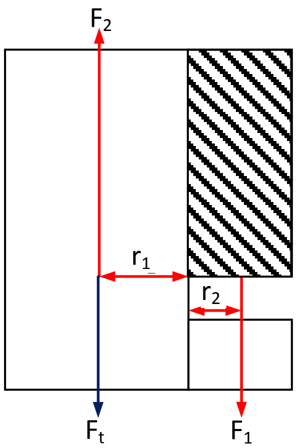

Figure 1: Side view of a tree after 50,000 punches. The hatching shows the section that would be acting downwards, pulling on the tree. F_1 is the force due to gravity on the overhang and F_2 is the force this exerts on the still attached section of tree. F_t is the force holding the tree together. r_1 and r_2 are the distance that the centre of each force is from the pivot point.

To calculate the amount of force acting on the overhang of the tree, its mass must first be found by using the relationship between density and volume:

$$m = \rho V$$

Equation 3

A mid-range value of the height of an oak tree is 20m[5]. If the base of each punch was 0.95m from the bottom of the tree then there is a total of 19m overhanging the compressed section. As the density of a typical oak is about 740kg/m^3 [6] then the mass above the overhang is:

$$m = 740 \cdot (19 \cdot 1 \cdot 0.3) = 4218kg$$

As nothing is suspending this section of tree the force can therefore be calculated using the acceleration due to gravity:

$$F_1 = 4218 \cdot 9.806 = 41361.71N$$

However, this is the force acting downward on the overhang rather than upward on the attached section of tree. To calculate this value we must use an equation for the magnitude of torque[7]:

$$\tau = rF \cdot \sin\theta$$

Equation 4

Where *r* is the radius of the force from the point of action. As the force is acting perpendicular to the plane:

$$\sin\theta = \sin 90 = 1$$

This means the equation can be rewritten as:

$$\tau = rF$$

Equation 5

When the tree is stationary or at the moment before the tree breaks then the torque in each direction is equal, therefore:

$$r_1 F_1 = r_2 F_2$$

Equation 6

The force acting to break the tree is therefore:

$$F_2 = \frac{r_1 F_1}{r_2} = \frac{0.15 \cdot 41361.71}{0.35} = 17726.45N$$

As the tensile strength along the grain for oak is 101.4MN/m^2 [8] the total force holding the tree together is:

$$F_t = 101.4 \times 10^9 \cdot (0.7 \cdot 1) = 70980000N$$

Discussion

As the force holding the tree together is so much greater than the force attempting to break it, it would not topple after a total of 50,000 punches. As this is already a ludicrous number it is highly unlikely that felling a tree by punching it would be possible, even with the given assumptions.

However on further investigation it seems that the reason for this may be a flaw in the model. For example if we take that the tree has been compressed into a space 0.1m in depth then we find that the breaking force is about 1.1×10^6N whereas the holding force is still significantly greater at 1.0×10^{10}N.

Conclusion

The results of this model showed that it would be possible to compress a tree by punching it; however, the results were inconclusive as to whether it would cause the tree to topple. In order to improve this model another study should be conducted to find the point at which the tree would topple and to determine when it is no longer possible for a punch to compress the tree, hence finding if it is possible to fell a tree by punching it.

References

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