Self-Healing Concrete

A Probabilistic Approach

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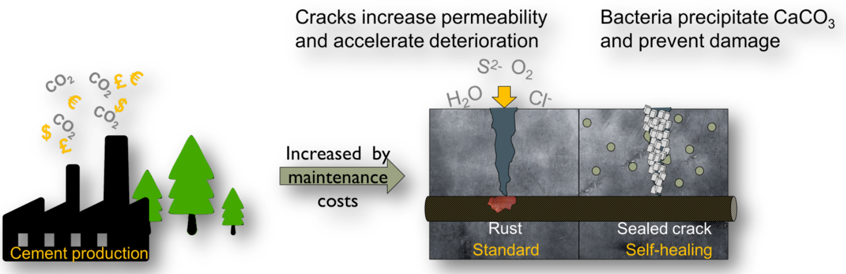
The Need For Self-Healing Concrete

What is Self-Healing Concrete?



Problems

1. *Find a way to classify the fitness of types of bacteria*
2. *Create a mathematical model to mimic the growth of a crack in concrete and the subsequent bacterial response*

Classifying Bacteria

We will define the **fitness** of a type of bacteria to be their ability to quickly grow so they can fill cracks faster.

One experimental way to determine fitness is to see how quickly bacteria moves through **lightweight aggregates**, seen below.

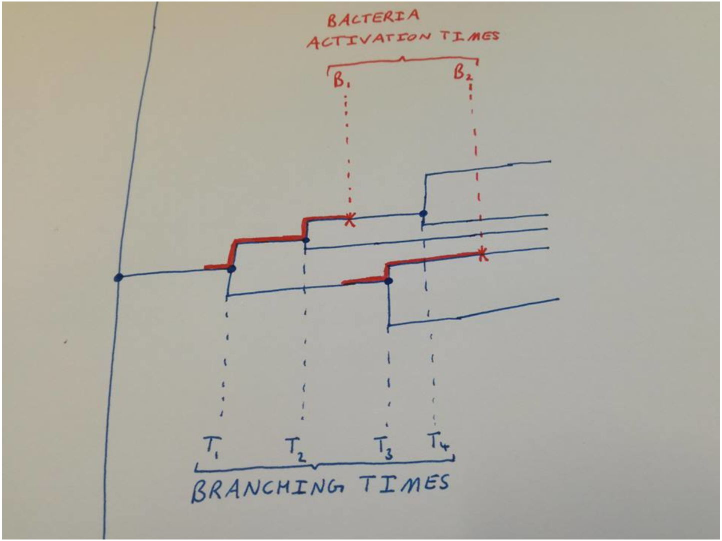
Go to simulation

Set-up to the Growth Model

Our idea is to model the crack as a branching process that will interact with randomly placed bacteria.

1. The branching process will branch at exponential rate with parameter 1.
2. The branching process will encounter a bacterial colony at an exponential rate with parameter ρ.
3. Once activated the bacterial colony moves up the branching process at a deterministic rate λ (the fitness of the bacteria).

The Growth Model



Extreme Case 1: $\lambda=\infty$

In the case $\lambda = \infty$ the bacterial colonies are **super-fit** and fill the crack instantaneously once activated.

Consequently, we need only know how long it takes for the **first** bacterial colony to be activated.

For example, one can see the depth the process reaches before activating a bacterial colony is distributed as an $Erlang(i, 1+\rho)$ random variable, where $i \sim Geom(\frac{\rho}{1+\rho})$ is the number of branches crossed.

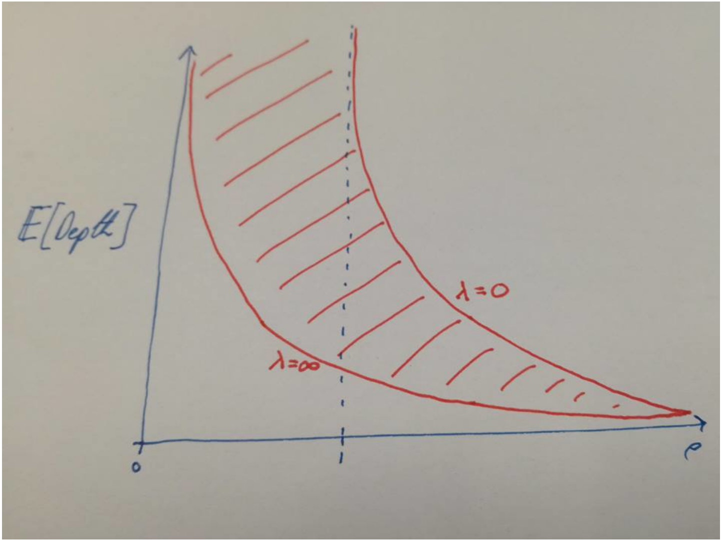
Extreme Case 2: λ=0

In the case where $\lambda = 0$, the bacteria do not grow. In this scenario, the only way for the bacteria to effectively seal the crack is for every branch to hit a colony.

Classical branching processes theory tells us that;

- if $\rho > 1$ the crack will cease to be connected to the surface with probability 1.
- if $\rho < 1$ the crack is always connected to the surface with positive probability.

$0 < \lambda < \infty$



Future Directions

- Better understand how first passage percolation models can determine the fitness of types of bacteria, and model their growth.
- Understand how ρ and λ affect our growth model.
- Consider changes to our growth model to make it more biologically and physically realistic. Would a spatial model be more appropriate?