# An Empirical Analysis of Data Streaming Algorithms

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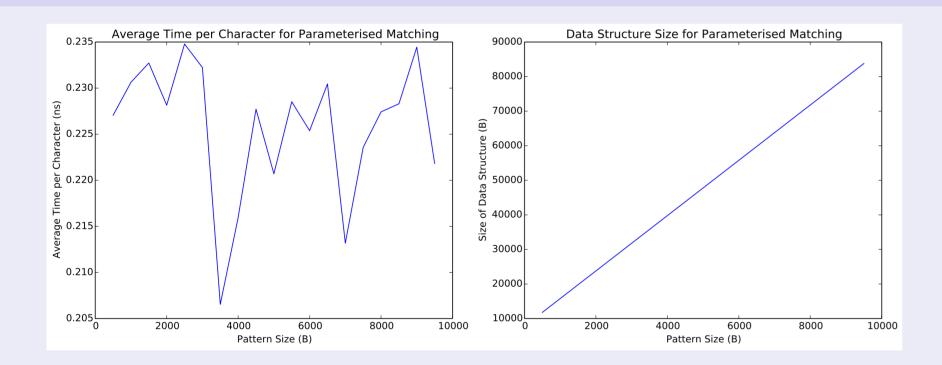
#### Introduction

In the wake of Big Data, a large amount of recent research in Theoretical Computer Science has been focused on the data streaming model. Under this model, the computer only has access to a window of the input at any time, and the objective is to compute the solution with a sublinear amount of space. There have been a number of theoretical developments in Data Streaming in recent years, but very few of these have ever been implemented to see if they are practical.

I have implemented two algorithms in C for stream-based pattern matching. Note the standard notation, where m is the length of the pattern and  $\Sigma$  is the alphabet:

- 1. An algorithm for parameterised matching with  $O(m + |\Sigma|)$  space and  $O(\log(\min(m, |\Sigma|))$  amortised time per character by Amir et al.<sup>a</sup>
- 2. An algorithm for exact matching with  $O(\log m)$  space and O(1) time per character by Breslauer and Galil,<sup>b</sup> and deamortised by Simon's Algorithm.<sup>c</sup> Sublinear space is achieved via Karp-Rabin fingerprints. All of these algorithms have been tested on 50MB of English text from the Pizza and Chili Corpus.

### Parameterised Matching Results

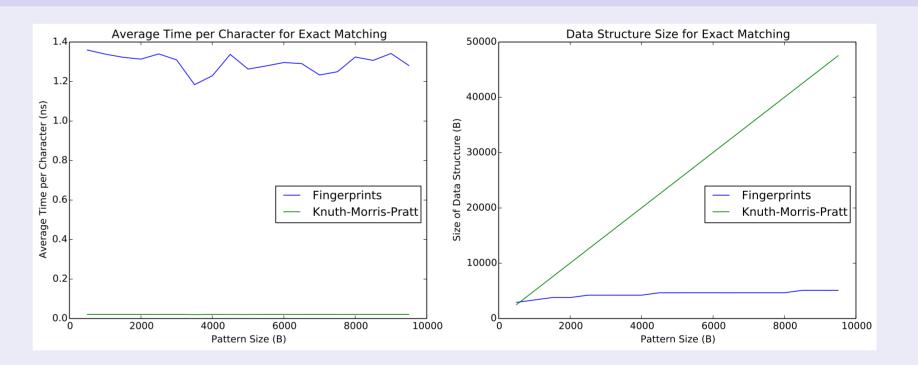


# Parameterised Matching Conclusions

The main bottleneck in Parameterised Matching is that previous occurances of characters in the text are stored in a search tree, which takes  $O(\log \pi)$  time to query and edit.

Question: Can this be improved with dynamic hashing, for which the best results are  $O(\sqrt{\log \pi / \log \log \pi})$ ?

### Results for Exact Matching



## **Exact Matching Conclusions**

Exact matching with Fingerprints takes 60-70 times longer per character and a significantly longer build time than Knuth-Morris-Pratt, but requires less space than even storing the pattern.

Question: The practical bottleneck is that the fingerprints use a lot of modular multiplications. Could these be optimised via precomputation or Montgomery Multiplication?





<sup>&</sup>lt;sup>a</sup>Alphabet Dependence in Parameterized Matching by Amihood Amir, Martin Farach and S. Muthukrishnan

<sup>&</sup>lt;sup>b</sup>Real-Time Streaming String-Matching by Dany Breslauer and Zvi Galil

<sup>&</sup>lt;sup>c</sup>String Matching Algorithms and Automata by Imre Simon