Time complexity.

- Preprocessing: $O(m)$
- Search: $O(n)$

EXPERIMENTAL RESULTS

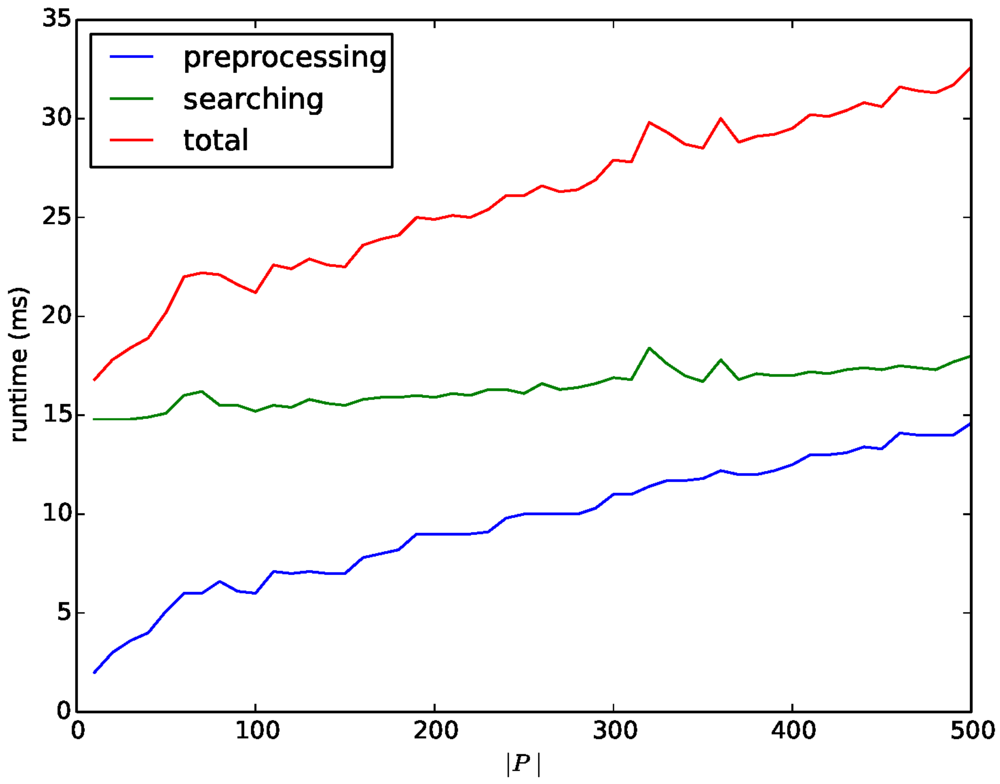
METHODOLOGY

Implementations. The algorithms introduced above were implemented with java version 1.7. The source code for the implementations can be viewed on github at `https://github.com/psaikko/string-algorithms-project`.

Experiments. The experiment data was gathered using python scripts to automate running the algorithms. Every plotted data point is an average of 10 runs of the algorithm.

COMPARISON WITH THEORETICAL PERFORMANCE

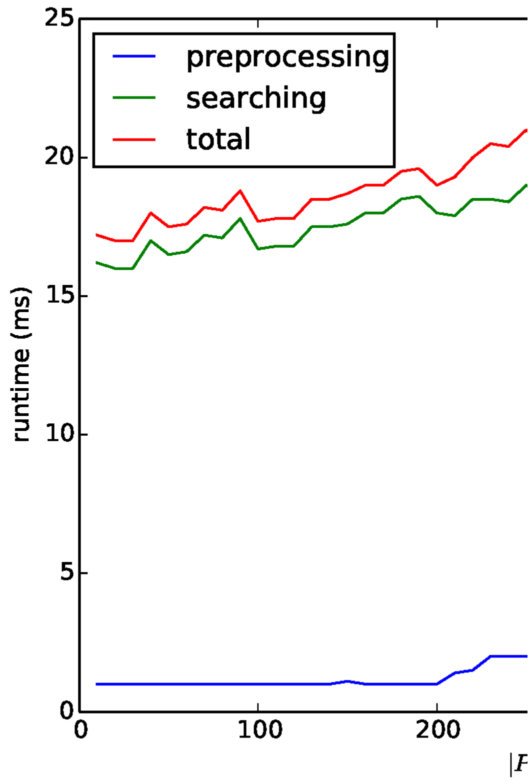
With constant text length. We plot the preprocessing and search times for each algorithm as the number of patterns to search for is increased.



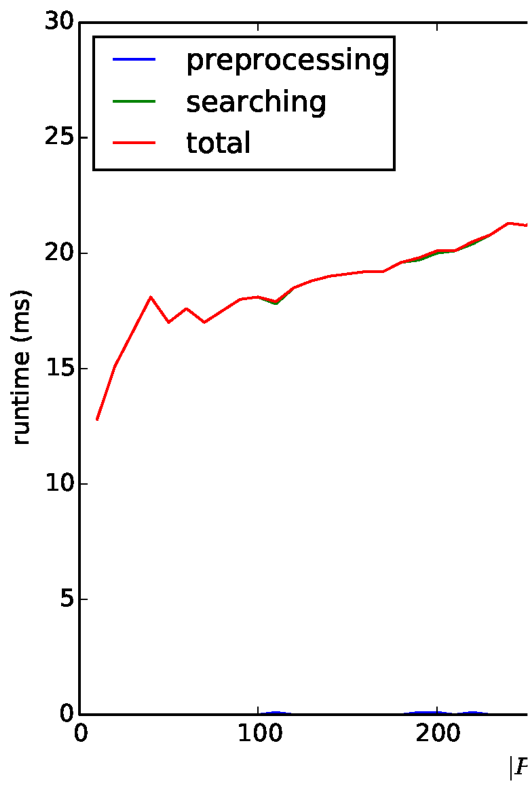
Aho-Corasick. We see search time staying roughly constant as expected, while preprocessing time increases linearly as we add more patterns.

Time complexity.

- Preprocessing: $O(m)$
- Search: $O(n\lceil m/w \rceil)$



Karp-Rabin. The algorit well despite poor worst-c preprocessing is quite fas



Shift-And. The preproce is much shorter than th spite the same asymptoti

1)

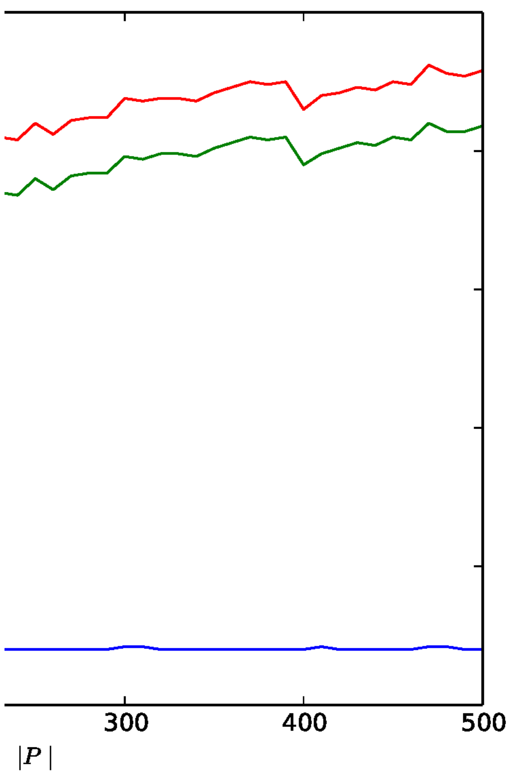
)

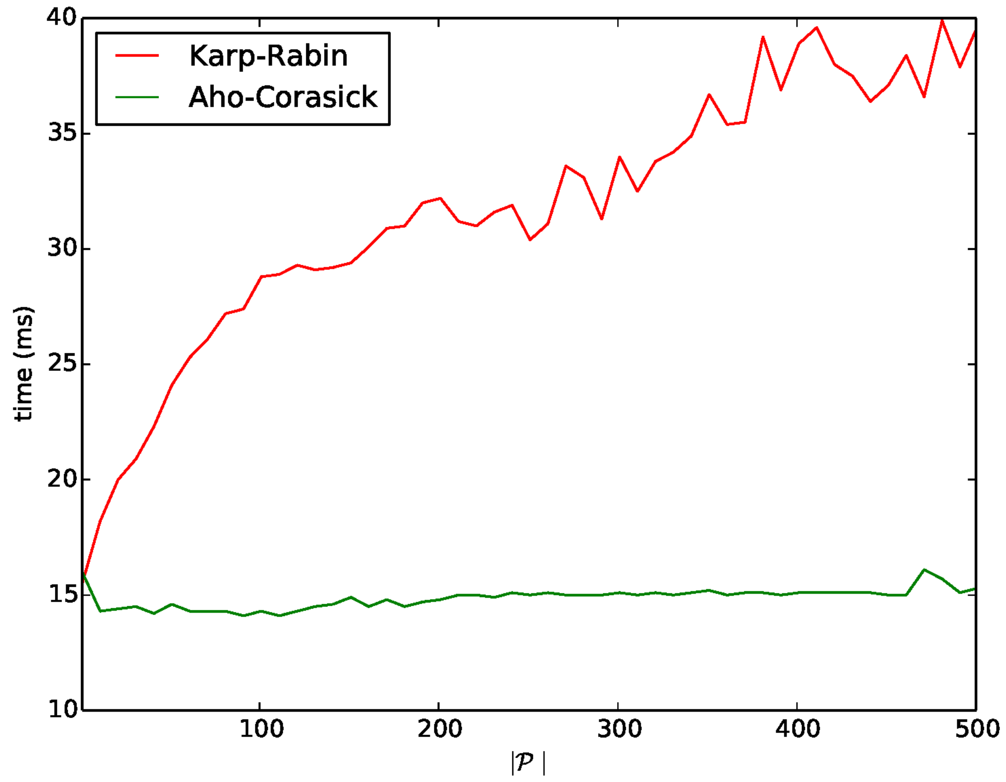
behavior.

Average time complexity.

- Preprocessing: $O(m)$
- Search: $O(n+m)$

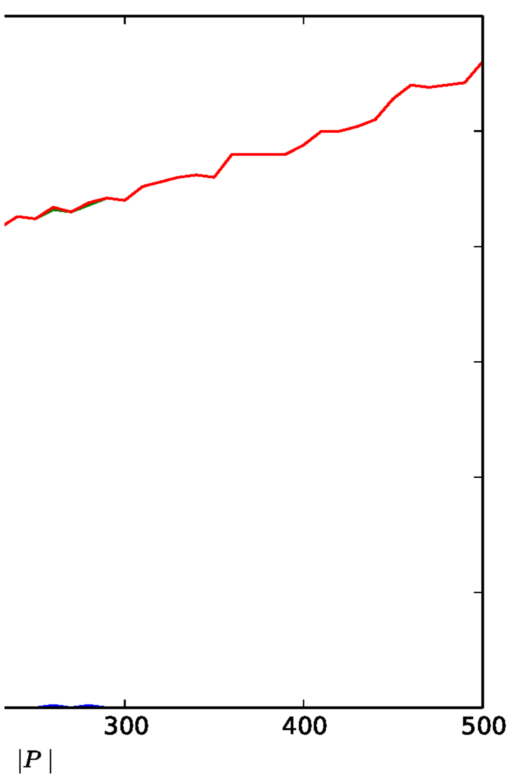
EDGE CASES

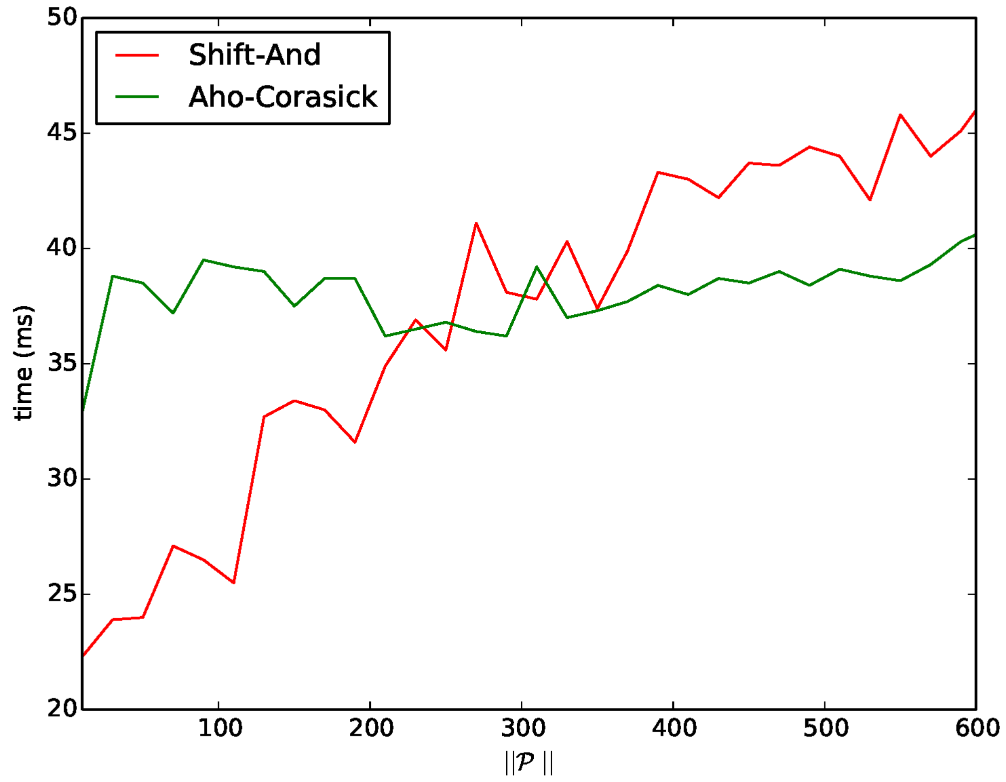




ithm generally performs -case behavior for search, ast.

Many short patterns. A combination of the Karp-Rabin algorithm's $O(n+m)$ time complexity and hash collisions leads it to perform poorly.





essing time for Shift-And he other algorithms, de- tic time complexity.

Small total pattern length. Although Shift-And scales poorly with total pattern length, the bit-parallel algorithm is fast when $\|\mathcal{P}\|$ is not large.

EXPERIMENTAL COMPARISO
STRING MATCHING ALGORIT

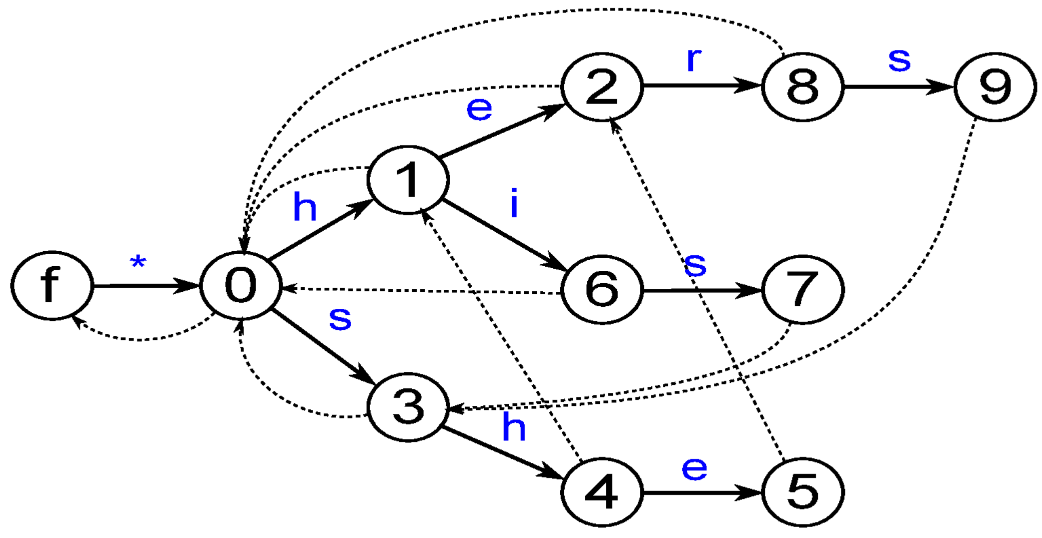
The *multiple exact string matching* problem asks us to search a text T o
we could search the text for each pattern in P using some exact string ma
give an overview of three such algorithms: Aho-Corasick, Shift-And, and
We compare the theoretical performance of these algorithms to experin
each approach, assuming a constant alphabet size of σ and equal-lengt

THE ALGORITHMS

AHO-CORASICK

The algorithm. We can construct a trie from the patterns $\mathcal{P}$, then for each node, add a link to the node that represents the longest proper suffix of the node and make note of pattern occurrences. The automaton can be then simulated with the text T as input to find occurrences.

Aho-Corasick automaton. For the patterns $\mathcal{P} = \{\text{he}, \text{she}, \text{his}, \text{hers}\}$ we can produce the following automaton:



SHIFT-AND

The algorithm. Shift-An
taining a bitvector D wl
longest prefixes of patter

```
# preprocessing
for (i = 0; i < m;
  B[P[i/l][i%l]] +=
for (i = 0; i < m;
  pBegin += 2^i
for (i = l - 1; i
  pEnd += 2^i
# search
for (i = 0; i < n;
  D = ((D << 1) | p
  if D & pEnd ≠ 0:
```

Bitparallelism. The bit
pEnd can be represented
B can be stored in $\sigma\lceil m/w$
in $O(\lceil m/w \rceil)$ bitwise ope

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ON OF MULTIPLE EXACT THMS

Paul Saikko

of length n for a set of patterns $\mathcal{P}$ with total length $\|\mathcal{P}\| = m$. Obviously
atching algorithm, but much better algorithms for this task exist. Here we
d Karp-Rabin. Each provides a different approach to solving the problem.
imental results and attempt to identify the strenghts and weaknesses of
th patterns, $|P_j| = l$ for every $P_j \in \mathcal{P}$.

nd scans the text, it main-
which keeps track of the
erns it has encountered.

```
; i++):
= 2^i
; i += l):

 < m; i += l):


; i++):
pBegin) & B[T[i]]
: yield i
```

tvectors D, pBegin, and
d in $\lceil m/w \rceil$ machine words.
$w\rceil$ and D can be updated
operations at each step.

KARP-RABIN

Karp-Rabin hash function. For some fixed positive integers r and q, the karp-rabin hash of a string $S = s_0 s_1 \ldots s_{m-1}$ is

$$H(S) = \sum_{i=0}^{m-1} (s_i r^{m-1-i}) \mod q.$$

This is an example of a rolling hash function – if we know the hash $H(T_{[i \ldots i+m]})$, we can compute $H(T_{[i+1 \ldots i+1+m]})$ in constant time.

Multiple string matching. We can precompute the hash value for every pattern and store them in a data structure that supports constant-time lookups. Potential occurrences in the text can be found by computing $H(T_{[i \ldots i+l]})$ for each $i \in [0 \ldots n-l)$, and comparing them to the precomputed pattern hashes. Every potential occurrence must be checked, which leads to poor worst-case