Algorithm Complexity II

Logarithmic Time Complexity

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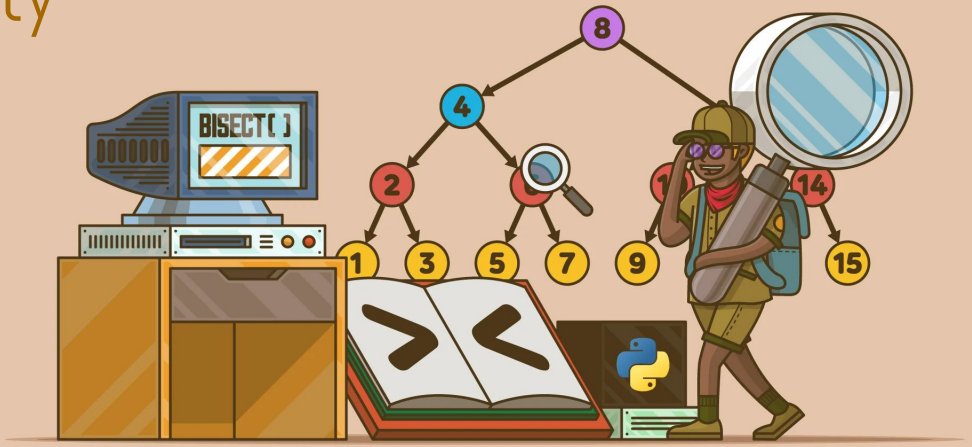

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Real Python

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A Compressed Sensing Approach to Pooled RT-PCR Testing for COVID-19 Detection

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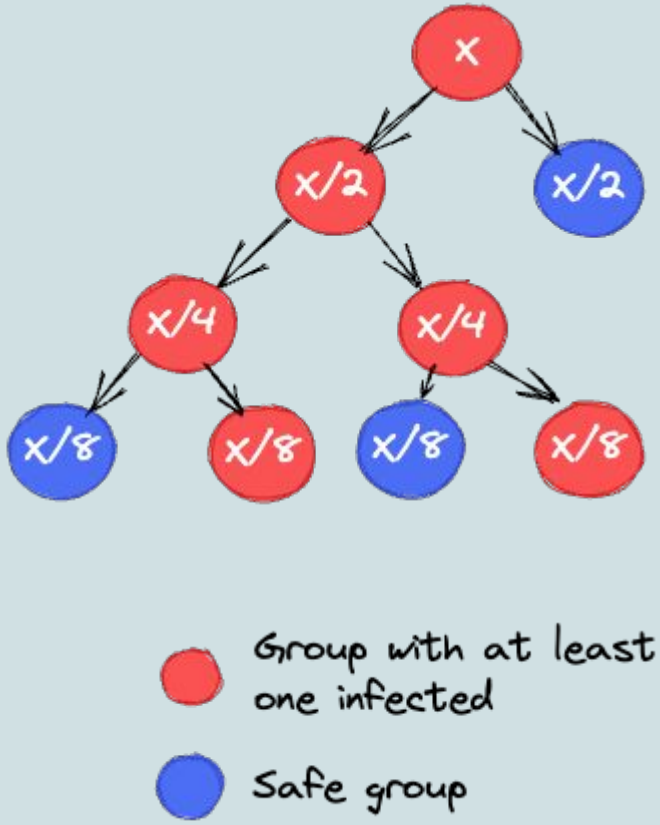
ABSTRACT We propose 'Tapestry', a single-round pooled testing method with application to COVID-19 testing using quantitative Reverse Transcription Polymerase Chain Reaction (RT-PCR) that can result in shorter testing time and conservation of reagents and testing kits, at clinically acceptable false positive or false negative rates. Tapestry combines ideas from compressed sensing and combinatorial group testing to create a new kind of algorithm that is very effective in deconvoluting pooled tests. Unlike Boolean group testing algorithms, the input is a quantitative readout from each test and the output is a list of viral loads for each sample relative to the pool with the highest viral load. For guaranteed recovery of k infected samples out of $n \gg k$ being tested, Tapestry needs only $O(k \log n)$ tests with high probability, using random binary pooling matrices. However, we propose deterministic binary pooling matrices based on combinatorial design ideas of Kirkman Triple Systems, which balance between good reconstruction properties and matrix sparsity for ease of pooling while requiring fewer tests in practice. This enables large savings using Tapestry at low prevalence rates while maintaining viability at prevalence rates as high as 9.5%. Empirically we find that single-round Tapestry pooling improves over two-round Dorfman pooling by almost a factor of 2 in the number of tests required. We evaluate Tapestry in simulations with synthetic data obtained using a novel noise model for RT-PCR, and validate it in wet lab experiments with oligomers in quantitative RT-PCR assays. Lastly, we describe use-case scenarios for deployment.

INDEX TERMS Compressed sensing, coronavirus, COVID-19, group testing, Kirkman/Steiner triples, mutual coherence, pooled testing, sensing matrix design.

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ORIGINAL RESEARCH

Anti-collision algorithm based on slotted random regressive-style binary search tree in RFID technology

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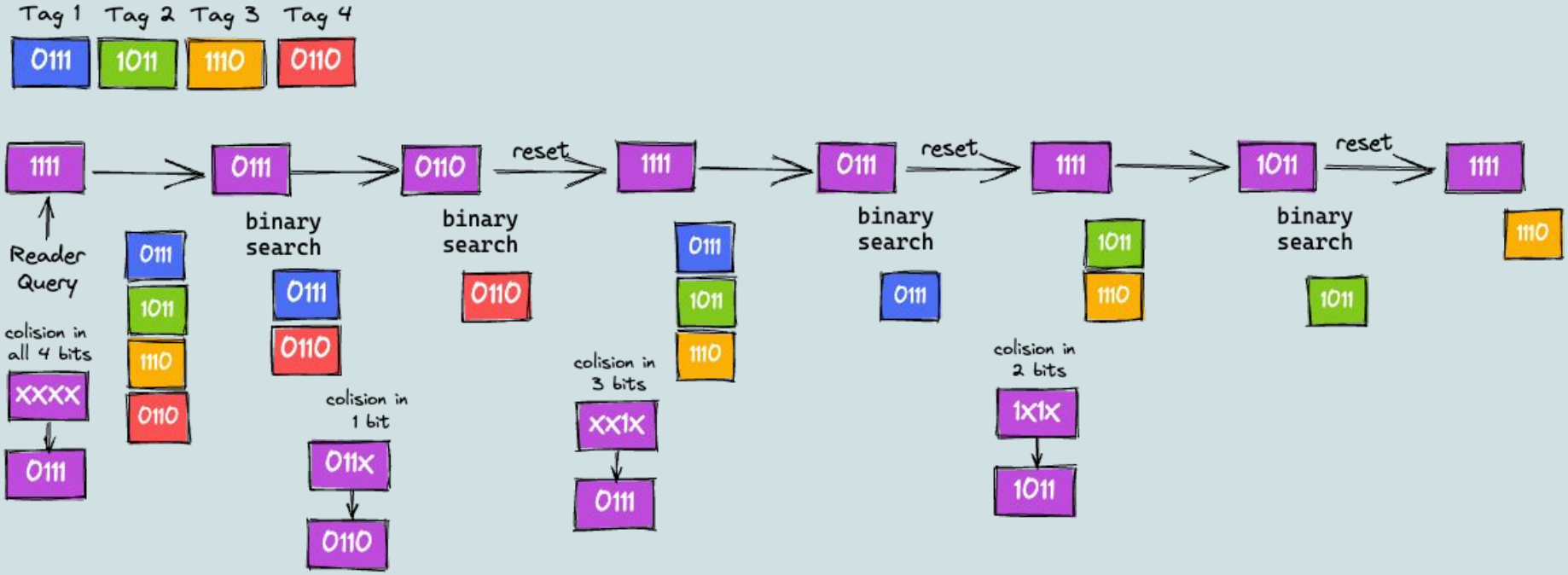
Abstract

In recent years, the rapid development of the Internet of Things (IoT) technology has provided a strong technical support for the technological transformation of the logistics industry. The informatization development of logistics industry increasingly relies on the Internet of Things technology represented by Radio Frequency Identification (RFID) technology. These technologies lead the whole business process to optimize the business process in the direction of accurate, efficient and real-time. In order to solve the problem that the reader cannot identify the label information correctly due to the phenomenon of data collision in the application of RFID technology, this paper proposes an anti-collision algorithm based on Slotted Random Regressive-style Binary Search Tree (SR-RBST). Based on Slotted ALOHA (SA) the method proposed in this paper uses the Regressive-style Binary Search Tree (RBST) to process the RFID labels in the collision time slot. With the same size of tags, the SR-RBST algorithm needs less total time slot and has higher efficiency and shorter identification time, while with the increase of the number of tags, the SR-RBST anti-collision algorithm has more obvious advantages. The SR-RBST algorithm effectively improves the time slot utilization efficiency of the system.

How a RFID tag communicate with a reader?

Medium Access Control for RFID



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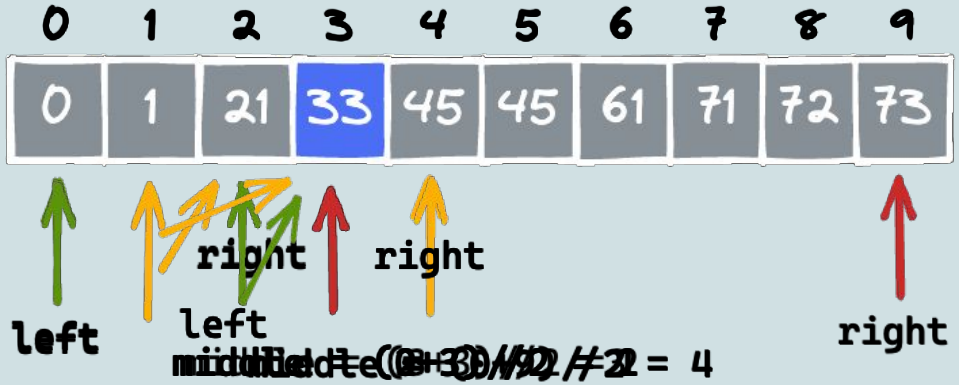
Binary Search Algorithm

Target = 33

array[middle] == target?

array[middle] < target?

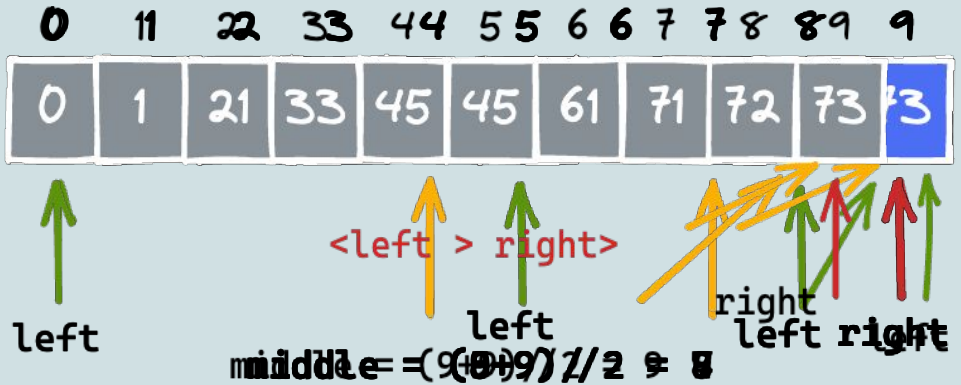


Binary Search Algorithm

Target = 74

array[middle] == target?

array[middle] < target?



```
1:def binarySearch(array, target, left, right):
2:    if (left > right) or (right < left):
3:        return -1
4:    middle = (left + right)//2
5:    potentialMatch = array[middle]
6:    if target == potentialMatch:
7:        return middle
8:    elif target < potentialMatch:
9:        return binarySearch(array, target, left, middle-1)
10:   else:
11:       return binarySearch(array, target, middle+1, right)
```

```
1:def binarySearch(array, target, left, right):
2:    while left <= right:
3:        middle = (left + right)//2
4:        potentialMatch = array[middle]
5:        if target == potentialMatch:
6:            return middle
7:        elif target < potentialMatch:
8:            right = middle -1
9:        else:
10:           left = middle + 1
11:   return -1
```

How to calculate the time complexity?

$$N \rightarrow \frac{N}{2} \rightarrow \frac{N}{2^2} \rightarrow \frac{N}{2^3} \rightarrow \ldots \rightarrow \frac{N}{2^k}$$

In the worst case scenario:

$$\frac{N}{2^k} = 1$$

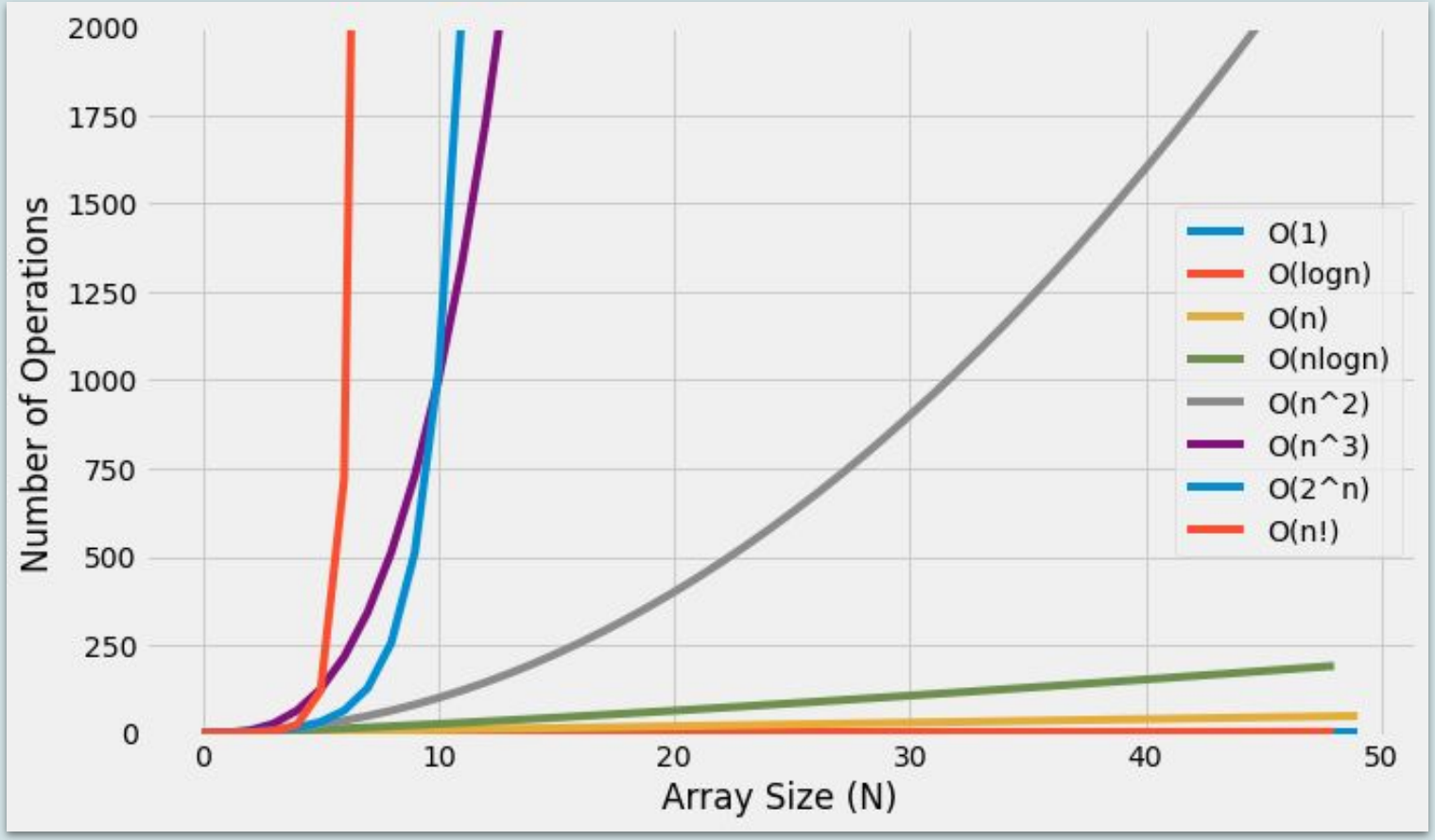
$$2^k = N$$
$$log2^k = logN$$
$$k = logN$$
$$O(logN)$$

Binary Search vs Linear Search

O(logN)*

O(N)

O(NlogN) + O(logN)



$$O(1) < O(logn) < O(n) < O(nlogn) < O(n^2) < O(2^n) < O(n!)$$

How to benchmark and compare algorithms?
Are there some python package available?
Manual evaluation using different scenarios? How to guarantee the same input?
How many experiments is necessary to investigate in order to obtain a target confidence interval?