

Quick Permutation Test: feature filtering of n-gram data

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Introduction

N-grams (k-tuples) are vectors of n characters derived from input sequence(s). They may form continuous sub-sequences or be discontinuous. Another important n-gram parameter is its position. Instead of just counting n-grams, one may want to count how many n-grams occur at a given position in multiple (e.g. related) sequences.

	P1	P2	P3	P4	P5	P6
S1	3	2	2	3	1	4
S2	4	4	2	4	2	3
S3	3	4	1	4	3	1

Sample sequences.

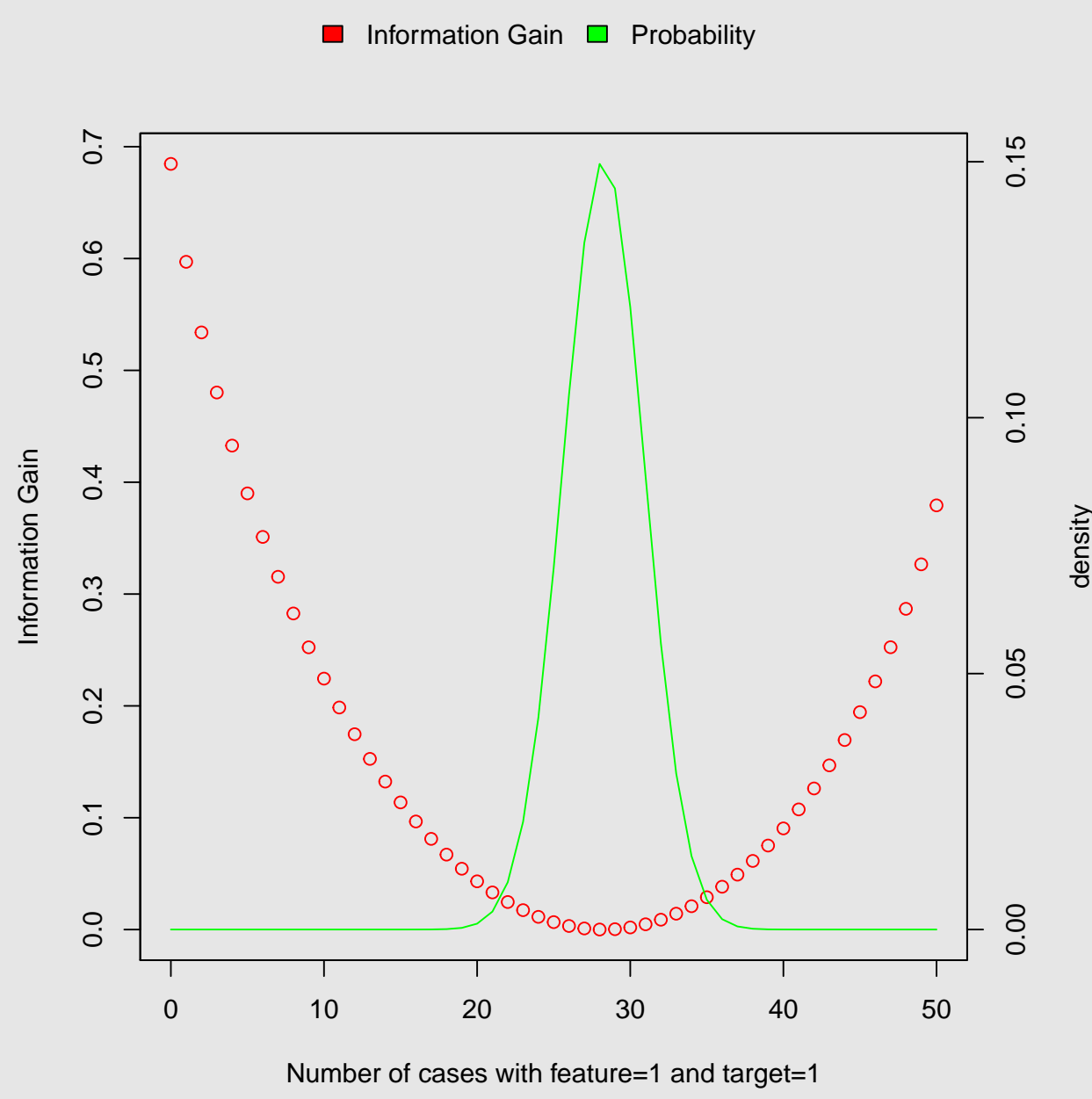
1	2	3	4
1	2	2	1
0	2	1	3
2	0	2	2

Unigram counts.

P1_1	P2_1	P3_1	P4_1	P5_1	P6_1	P1_2	P2_2	P3_2	P4_2	P5_2	P6_2
0	0	0	0	1	0	0	1	1	0	0	0
0	0	0	0	0	0	0	0	1	0	1	1
0	0	1	0	0	1	0	0	0	0	0	0

A fraction of possible unigrams with position information.

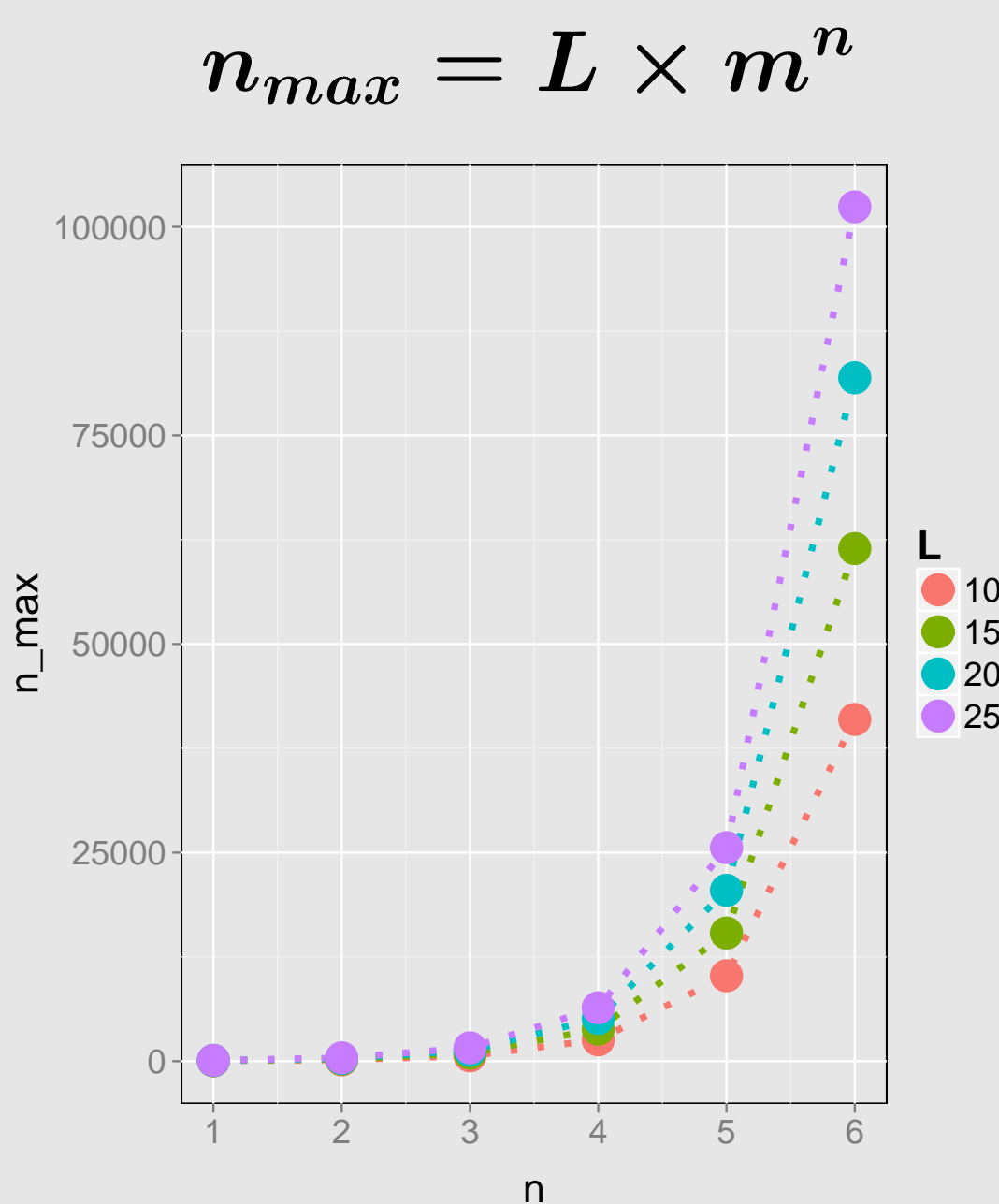
Validation procedure



	Target	Feature	Freq
1	0	0	40
2	1	0	10
3	0	1	25
4	1	1	40

Curse of dimensionality

Number of possible positioned n-grams (not taking into account distances between elemnts of n-gram):



Permutation test

During permutation tests class labels are randomly exchanged during computation of significance statistic. p-values are defined as:

$$\text{p-value} = \frac{N_{T_P > T_R}}{N}$$

where $N_{T_P > T_R}$ is number of times when T_P (permuted test statistic) was more extreme than T_R (test statistic for non-permuted data). Permutation tests are model and statistic independent, but computationally expensive (especially precise estimation of low p-values, because the number of permutations is inversely proportional to the interval between p-values).

QuiPT algorithm

If probability that target equals 1 is p and probability that feature equals 1 is q and feature and target are independent then each of them has the following probabilities

$$P(\text{Target}, \text{Feature}) = (1, 1)) = p \cdot q$$

$$P(\text{Target}, \text{Feature}) = (1, 0)) = p \cdot (1 - q)$$

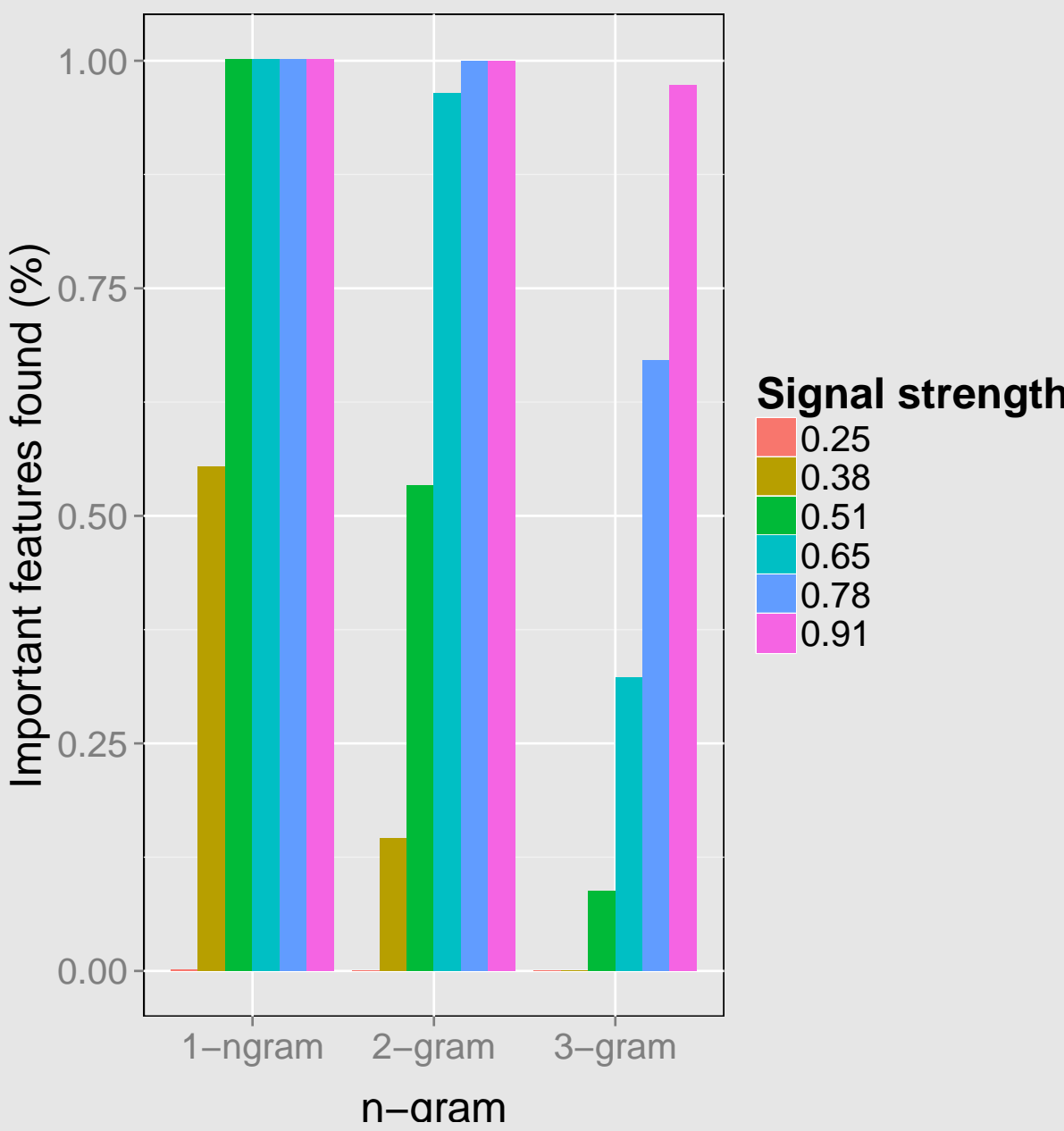
$$P(\text{Target}, \text{Feature}) = (0, 1)) = (1 - p) \cdot q$$

$$P(\text{Target}, \text{Feature}) = (0, 0)) = (1 - p) \cdot (1 - q)$$

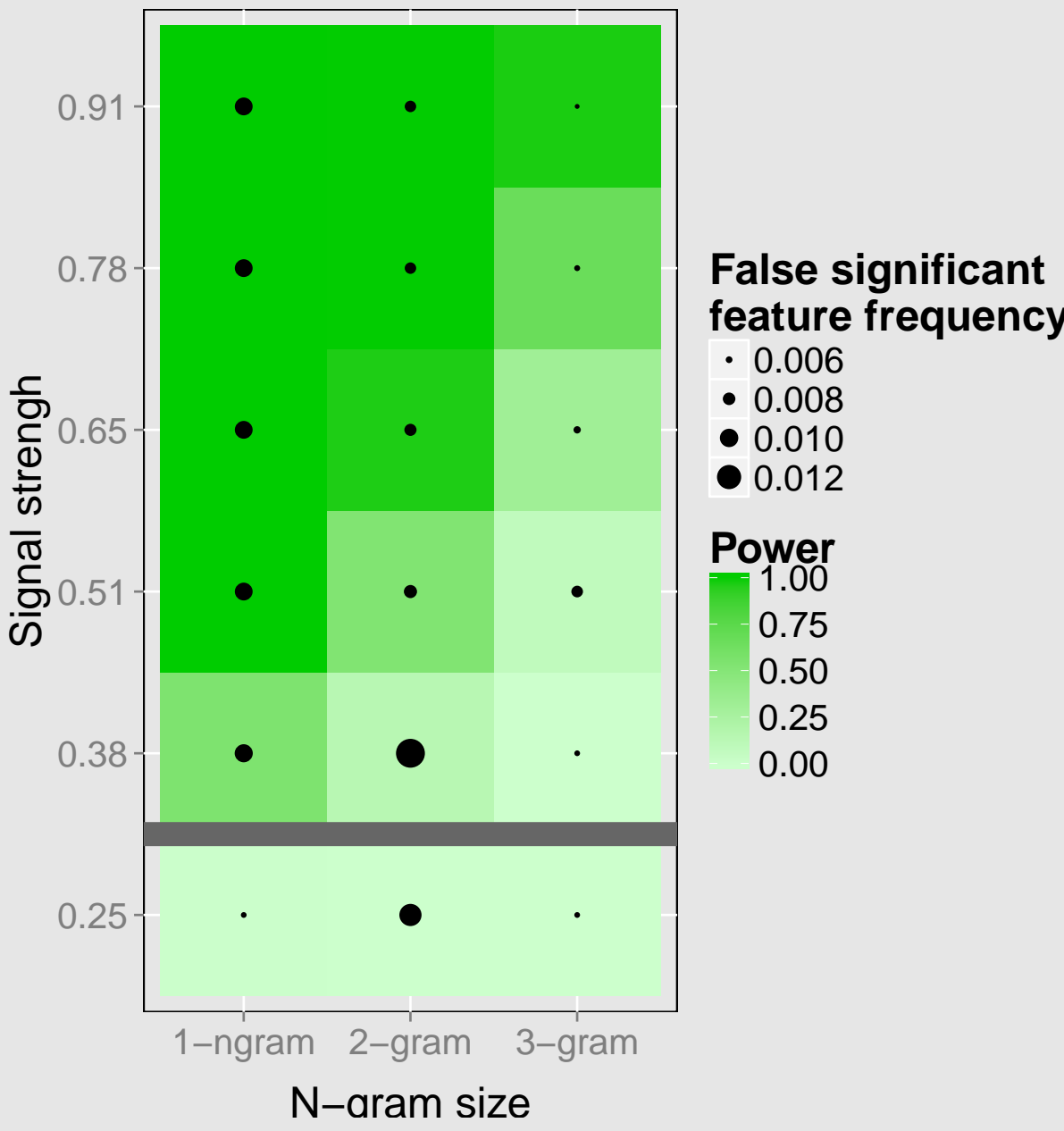
$$F(n_{1,1}, n_{1,0}, n_{0,1}, n_{0,0}) = \binom{n}{n_{1,1}} (p \cdot q)^{n_{1,1}} n - n_{1,1} \binom{n}{n_{1,0}} (p \cdot (1 - q))^{n_{1,0}} n - n_{1,1} - n_{1,0} \binom{n}{n_{0,1}} ((1 - p) \cdot q)^{n_{0,1}} n - n_{1,1} - n_{1,0} - n_{0,1} \binom{n}{n_{0,0}} ((1 - p) \cdot (1 - q))^{n_{0,0}} n_{0,0}$$

In addition to this: $n_{1,\cdot} = n_{1,1} + n_{1,0}$ and $n_{\cdot,1} = n_{1,1} + n_{0,1}$ are known and fixed.

Test power



False discoveries



Summary

Quick permutation test is a powerful and quick equivalent of permutation test in binary feature-binary target testing scenario.

Avaiability

biogram R package:
<http://cran.r-project.org/web/packages/biogram/>

Bibliography