

Криптографія

Комп'ютерний практикум № 1

Експериментальна оцінка ентропії на символ джерела відкритого тексту

Виконали
Студенти 3-го курсу
Групи ФБ-02
Замрій Денис та
Гнатюк Максим

Мета роботи:

Засвоєння понять ентропії на символ джерела та його надлишковості, вивчення та порівняння різних моделей джерела відкритого тексту для наближеного визначення ентропії, набуття практичних навичок щодо оцінки ентропії на символ джерела.

Порядок виконання роботи:

1. Написати програми для підрахунку частот букв і частот біграм в тексті, а також підрахунку H_1 та H_2 за безпосереднім означенням.
2. Підрахувати частоти букв та біграм, а також значення H_1 та H_2 на добровільно вибраному тексті російською мовою, достатньої довжини, де імовірності замінити відповідними частотам. Також одержати значення H_1 та H_2 на тому ж тексті у якому вилучені всі пробіли.
3. За допомогою програми CoolPinkProgram оцінити значення H^{10} , H^{20} , H^{30}
4. Використовуючи отримані значення ентропії, оцінити надлишковість російської мови в різних моделях джерела.

Формули, які використовували в лабораторній роботі:

Надлишковість:

$$R = 1 - \frac{H_{\text{ex}}}{H_0}$$

Ентропія:

$$\sum_{i=1}^{m-1} i(q_i^{(n)} - q_{i+1}^{(n)}) \log_2 i + m q_m^{(n)} \log_2 m \leq H^{(n)} \leq - \sum_{i=1}^m q_i^{(n)} \log_2 q_i^{(n)}$$

Ентропія символів в тексті з пробілами

('о',	0.11299019607843137)
('е',	0.08412990196078432)
('и',	0.07549019607843137)
('а',	0.07395833333333333)
('н',	0.06752450980392156)
('т',	0.0616421568627451)
('с',	0.050490196078431374)
('л',	0.04356617647058823)
('в',	0.04344362745098039)
('р',	0.04295343137254902)

Частота букв в тексті без пробілів

	о	е	и	а	н	т	с	л	в	р	к	д	у	м	п	г	ы	ь	ч	я	б	з	ж	й	х	ш	ю	ц	щ	э	ф	ё	ъ
Частота	0.11299	0.08413	0.07549	0.07399	0.06752	0.06164	0.05049	0.04356	0.04344	0.04295	0.03364	0.03315	0.03174	0.03117	0.02751	0.01900	0.01854	0.01887	0.01826	0.01813	0.01666	0.01617	0.01188	0.01158	0.01066	0.00784	0.00612	0.00373	0.00361	0.00208	0.00128	0.00049	6.13e-05

Частота букв в тексті з пробілами

	о	е	и	а	н	т	с	л	в	р	к	д	у	м	п	г	ы	ь	ч	я	б	з	ж	й	х	ш	ю	ц	щ	э	ф	ё	ъ	
Частота	0.19364	0.09111	0.06784	0.06087	0.05964	0.05445	0.04971	0.04071	0.03513	0.03503	0.03464	0.02713	0.02673	0.02559	0.0251	0.02118	0.01581	0.01576	0.01532	0.01471	0.01463	0.01344	0.01304	0.00959	0.00934	0.0086	0.00632	0.00484	0.00301	0.00292	0.00168	0.00104	0.0004	4.9e-05

Частота біграм у тексті без пробілів

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Частота біграм в тексті з пробілами

A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Частота біграм в тексті без пробілів, з кроком 2

[illegible]

Частота біграм в тексті з пробілами, з кроком 2

A	0	0.00044	0.00316	0.00079	0.00135	0.00227	0	0.00144	0.00227	0	0.0004	0.00423	0.00092	0.00247	0.00435	0	0.00079	0.00139	0.00247	0.00404	0	0	0.00139	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227	0.00139	0.00139	0.00005	0.00053	0	0	0.00099	0.00227</
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	Ентропія
Букви без пробілів	4.467786963954832
Біграми без пробілів	0.00042877213780620667
Біграми без пробілів з кроком 2	0.00079622263706243
Букви з пробілами	4.311678472331937
Біграми з пробілами	0.08660949753713894
Біграми з пробілами з кроком 2	0.08627840422614752

	Надлишковість
Букви без пробілів	0.11430652359038007
Біграми без пробілів	0.99991500027007
Біграми без пробілів з кроком 2	0.9998421569333754
Букви з пробілами	0.15248944181531143
Біграми з пробілами	0.9829758957972353
Біграми з пробілами з кроком 2	0.9830409760388652

Для N^{10}

$$1.74812914310069 < H < 2.47282138963761$$
[illegible]

Для H^{20}

1.83661942091655 < H < 2.66133710430125

Лабораторная работа №1

Произвольная часть текста:
возьмет_на_себя_тру

Использованные буквы:

Порядок n-граммы:
5 символов
10 символов
15 символов
25 символов
30 символов
35 символов
40 символов
45 символов
50 символов

Введенный символ:
Символ по счету:
Номер эксперимента: 56

Неравенство для энтропии:
1.83661942091655 < H < 2.66133710430125

Двоичная таблица угаданных символов:

Вероятности:

$q[1]$	= 0.4903030
$q[2]$	= 0.1818181
$q[3]$	= 0.0727272
$q[4]$	= 0.0181818
$q[5]$	= 0.0181818
$q[6]$	= 0.0181818
$q[7]$	= 0.0181818
$q[8]$	= 0.0181818
$q[9]$	= 0.0181818
$q[10]$	= 0
$q[11]$	= 0.018181
$q[12]$	= 0
$q[13]$	= 0.018181
$q[14]$	= 0
$q[15]$	= 0
$q[16]$	= 0
$q[17]$	= 0.018181
$q[18]$	= 0
$q[19]$	= 0
$q[20]$	= 0
$q[21]$	= 0
$q[22]$	= 0.018181
$q[23]$	= 0
$q[24]$	= 0
$q[25]$	= 0
$q[26]$	= 0
$q[27]$	= 0.018181
$q[28]$	= 0.036363
$q[29]$	= 0
$q[30]$	= 0.018181
$q[31]$	= 0
$q[32]$	= 0

Строка состояния:

Для H^{30}

1.49985746249546 < H < 2.28750974088565

Лабораторная работа №1

Произвольная часть текста:
совершенно_ясно_что_они_знают_этот_закон_человеческой_природы_так_же_хорош

Использованные буквы:

Порядок n-граммы:
5 символов
10 символов
15 символов
20 символов
25 символов
30 символов
35 символов
40 символов
45 символов
50 символов

Введенный символ: (пробел)
Символ по счету: 1
Номер эксперимента: 54

Неравенство для энтропии:
1.49985746249546 < H < 2.28750974088565

Двоичная таблица угаданных символов:

Вероятности:

$q[1]$	= 0.6296296
$q[2]$	= 0.0555555
$q[3]$	= 0.0555555
$q[4]$	= 0.0555555
$q[5]$	= 0.0185185
$q[6]$	= 0.0185185
$q[7]$	= 0
$q[8]$	= 0
$q[9]$	= 0
$q[10]$	= 0.018518
$q[11]$	= 0.018518
$q[12]$	= 0
$q[13]$	= 0.018518
$q[14]$	= 0.018518
$q[15]$	= 0
$q[16]$	= 0
$q[17]$	= 0.018518
$q[18]$	= 0
$q[19]$	= 0
$q[20]$	= 0
$q[21]$	= 0.018518
$q[22]$	= 0
$q[23]$	= 0
$q[24]$	= 0.018518
$q[25]$	= 0
$q[26]$	= 0.018518
$q[27]$	= 0
$q[28]$	= 0
$q[29]$	= 0.018518
$q[30]$	= 0
$q[31]$	= 0
$q[32]$	= 0

Строка состояния:
Вы угадали. Для продолжения опыта нажмите "Продолжить", или "Другой" для выбора другого порядка

Висновок: На цій лабораторній роботі ми познайомились з поняттями ентропії та надлишковості. Більш поглиблено навчилися працювати з текстом в Python. Також навчилися обраховувати частоти букв і біграм в тексті. В лабораторній роботі використали програму PyCharm і CoolPinkProgram