

Криптографія

Комп'ютерний практикум № 1

Експериментальна оцінка ентропії на символ джерела відкритого тексту

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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:

$$R = 1 - \frac{H_{gr}}{H_0}$$

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	0.03112	0.02751	0.01960	0.01954	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	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000</
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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	0.00219	0.0005	0.0005	0	0	0.00099	0.00217	0.013	0	0	0.00099	0.00217	0.013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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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	Ентропія
Букви без пробілів	4.47983238661954
Біграми без пробілів	4.156467196560542
Біграми без пробілів з кроком 2	4.15516550078667
Букви з пробілами	4.034224557320984
Біграми з пробілами	3.664791134500426
Біграми з пробілами з кроком 2	3.6643626182742146

	Надлишковість
Букви без пробілів	0.11191864064949675
Біграми без пробілів	0.17602251168091476
Біграми без пробілів з кроком 2	0.17628055967301692
Букви з пробілами	0.2070262362192511
Біграми з пробілами	0.2796426728102185
Біграми з пробілами з кроком 2	0.27972690265908084

Для H^{10}

$1.74812914310069 < H < 2.47282138963761$

Лабораторная работа №1

Произвольная часть текста:

рядочного_поведения_или_морали_или_чего_то_в_этом_роде_относительно_чего_он

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

Поле ввода символов:

Продолжить Другой

Неравенство для энтропии:

$1.74812914310069 < H < 2.47282138963761$

Двоичная таблица угаданных символов:

10000000000000000000000000000000
10000000000000000000000000000000
10000000000000000000000000000000
01000000000000000000000000000000
00100000000000000000000000000000

Вероятности:

q[1] = 0,5740740
q[2] = 0,1296296
q[3] = 0,0185185
q[4] = 0,0370370
q[5] = 0
q[6] = 0,0185185
q[7] = 0,0185185
q[8] = 0
q[9] = 0
q[10] = 0,018518
q[11] = 0,018518
q[12] = 0
q[13] = 0
q[14] = 0
q[15] = 0
q[16] = 0
q[17] = 0
q[18] = 0,018518
q[19] = 0,018518
q[20] = 0,018518
q[21] = 0
q[22] = 0,037037
q[23] = 0,018518
q[24] = 0
q[25] = 0
q[26] = 0
q[27] = 0,018518
q[28] = 0
q[29] = 0
q[30] = 0
q[31] = 0,018518
q[32] = 0,018518

Строка состояния:

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

$H_{10} = 0.5816196851271386$
 $R_{H10} = 0.5816196851271386$

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

Поле ввода символов:

Продолжить Другой

Неравенство для энтропии:
1,83661942091655 < H < 2,66133710430125

Десятичная таблица угаданных символов:

00010000000000000000000000000000	^
10000000000000000000000000000000	
10000000000000000000000000000000	
00000010000000000000000000000000	
10000000000000000000000000000000	v

Вероятности:

q[1]	= 0,4909090
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:

R_H20: 0.5541628693584265

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:

01000000000000000000000000000000	
10000000000000000000000000000000	
10000000000000000000000000000000	
00100000000000000000000000000000	
10000000000000000000000000000000	
.....	

Вероятности:

$q[1] = 0,6296296$
$q[2] = 0,0555555$
$q[3] = 0,0555555$
$q[4] = 0,0555555$
$q[5] = 0,0185185$
$q[6] = 0,0185185$
$q[7] = 0$
$q[8] = 0$
$q[9] = 0$
$q[10] = 0,018518$
$q[11] = 0,018518$
$q[12] = 0$
$q[13] = 0,018518$
$q[14] = 0,018518$
$q[15] = 0$
$q[16] = 0$
$q[17] = 0,018518$
$q[18] = 0$
$q[19] = 0$
$q[20] = 0$
$q[21] = 0,018518$
$q[22] = 0$
$q[23] = 0$
$q[24] = 0,018518$
$q[25] = 0$
$q[26] = 0,018518$
$q[27] = 0$
$q[28] = 0$
$q[29] = 0,018518$
$q[30] = 0$
$q[31] = 0$
$q[32] = 0$

Поле ввода символов:

Продолжить Другой

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

R_H30: 0.6245964321596587

Висновок: На цій лабораторній роботі ми познайомились з поняттями аентропії 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