Quelques techniques d’extraction sémantique

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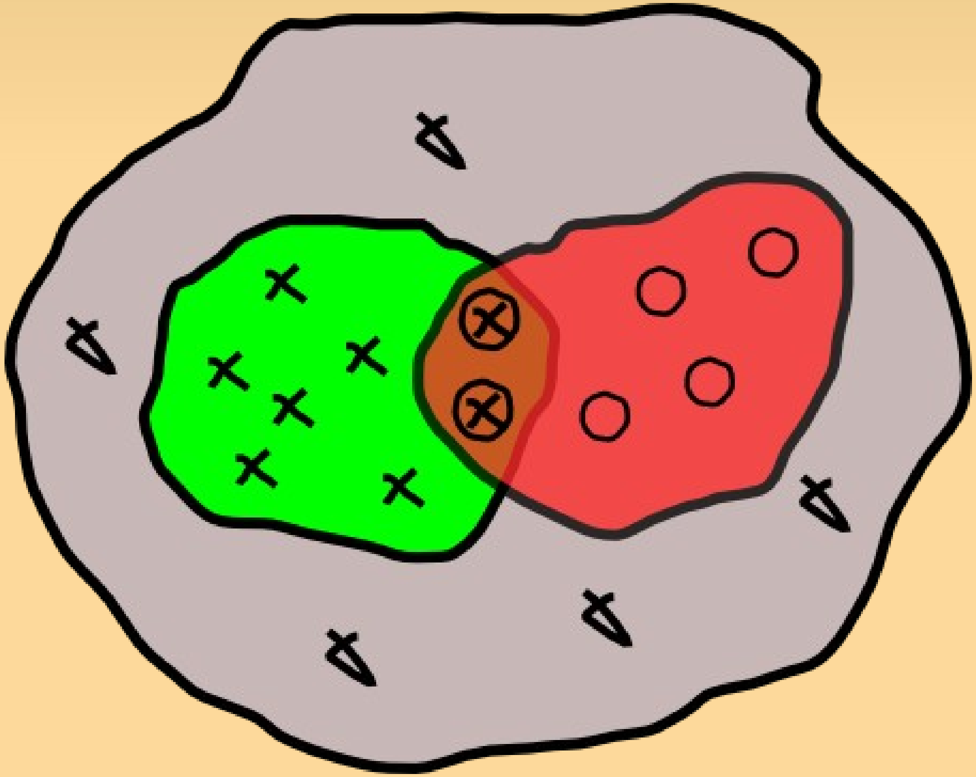
30 mars 2009

Qu’est-ce que le sens ?

Le sens est le contexte

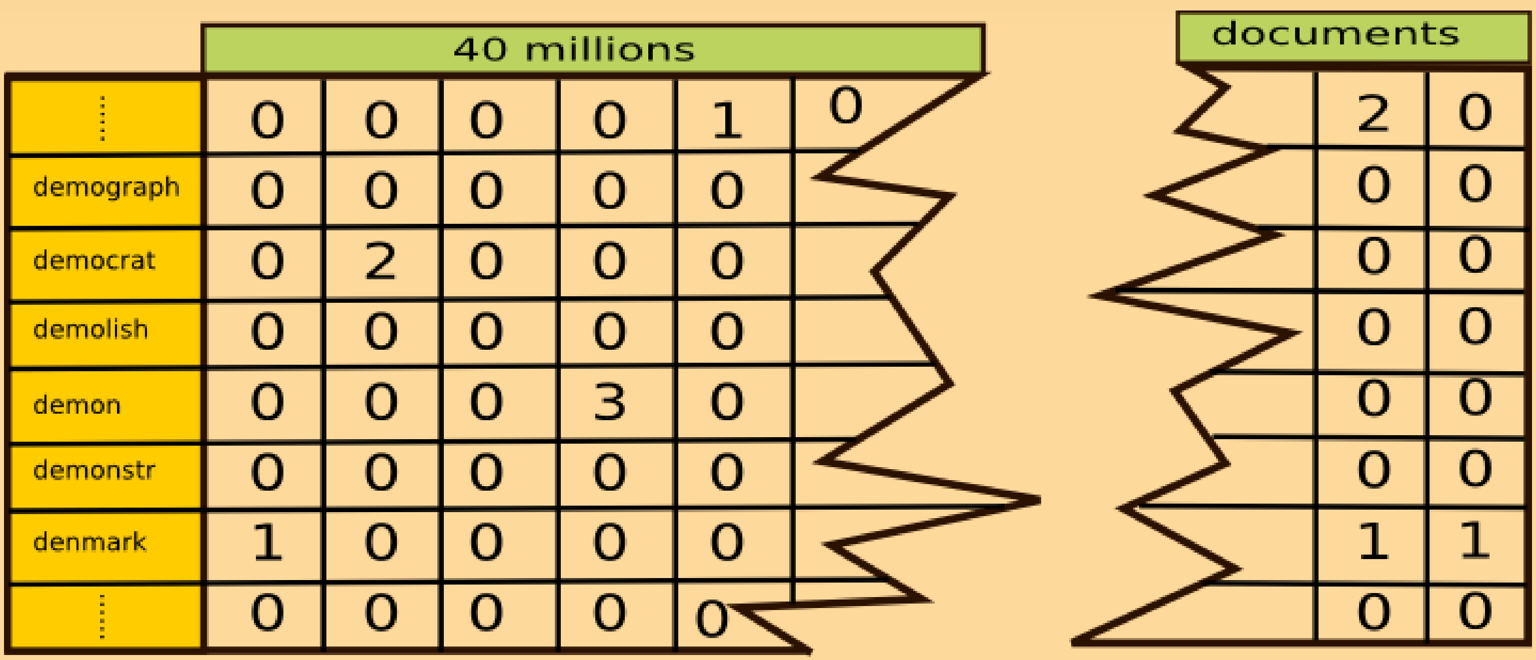


Plan

- Latent semantic analysis
- Complexité de Kolmogorov
- Distance informationnelle
- Quelques exemples

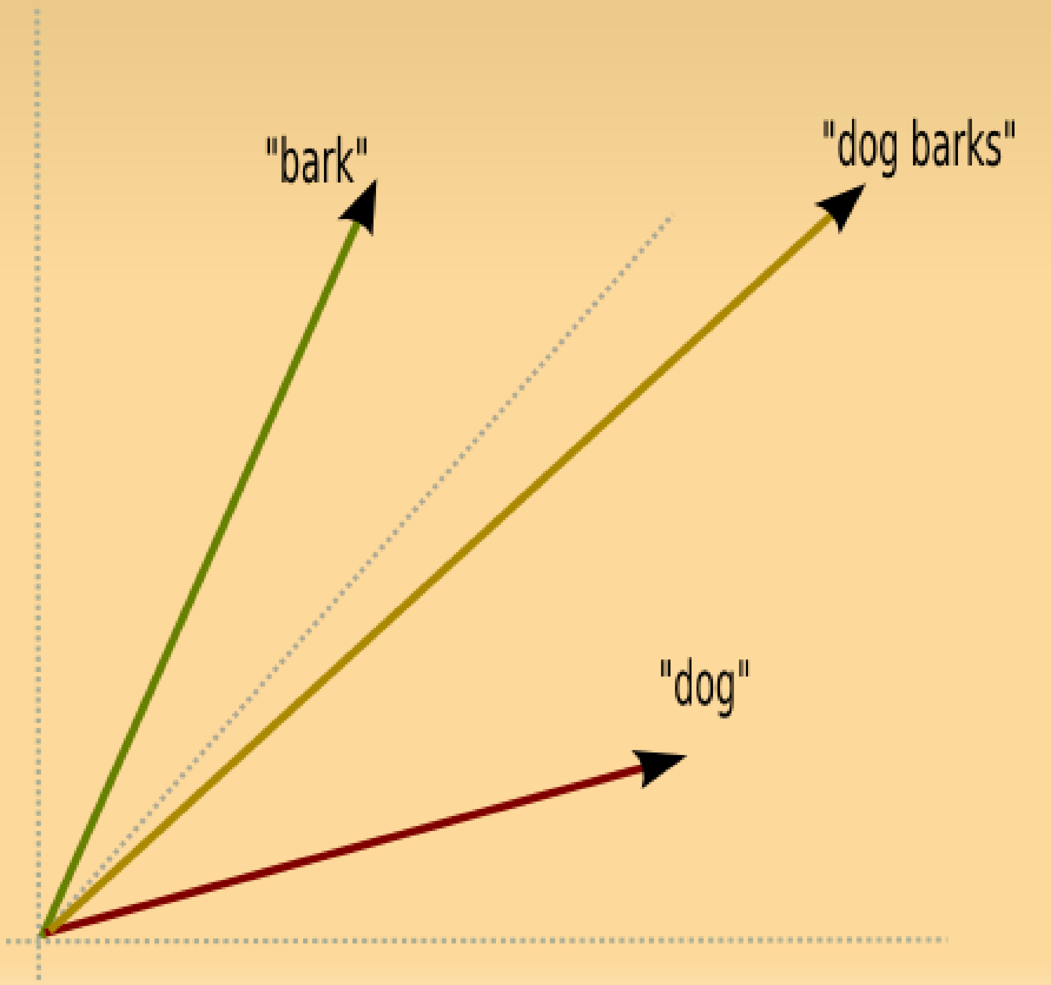
Latent Semantic Analysis

- Matrice éparse énorme: terms x documents
- Normalisation: log(cell)/entropie



Latent Semantic Analysis

- Tout mot/concept est un vecteur
- Tout prédicat/phrase est un vecteur
- Tout document est un vecteur



LSA

- SVD : réduction de dimensionalité
  - “compression” : approx 300 colonnes
- Mesure de similarité: cosinus des vecteurs
- Inconvenients
  - Non-incrémental
  - Passe mal à l’échelle
- Random indexing
  - Évite la grande matrice éparse du début

Kolmogorov complexity

011011011011011011011011011011011011011
011011011011011011011011011011011011011
011011011011011011011011011011011011011
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Kolmogorov complexity

01101101101101101101
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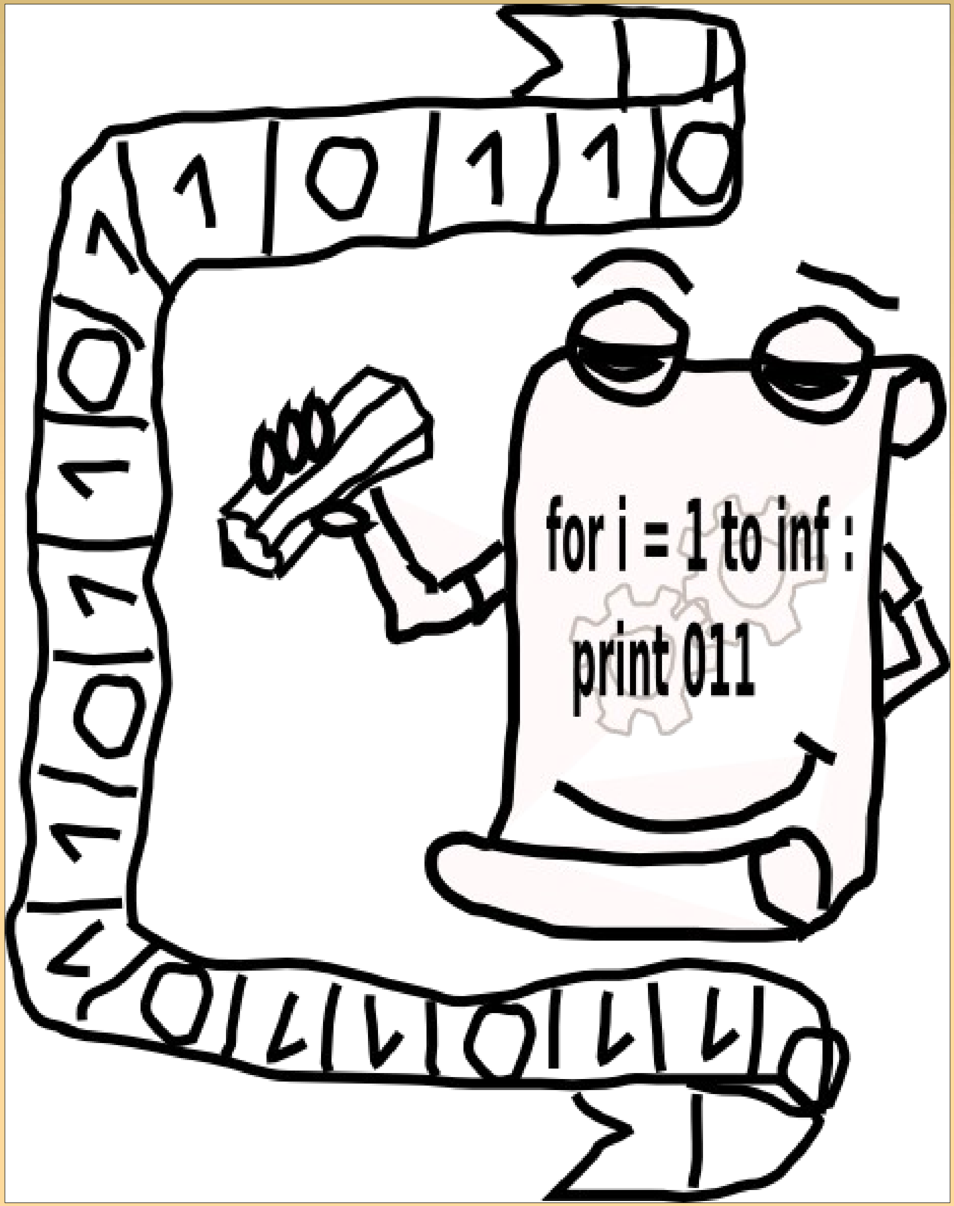


Kolmogorov complexity

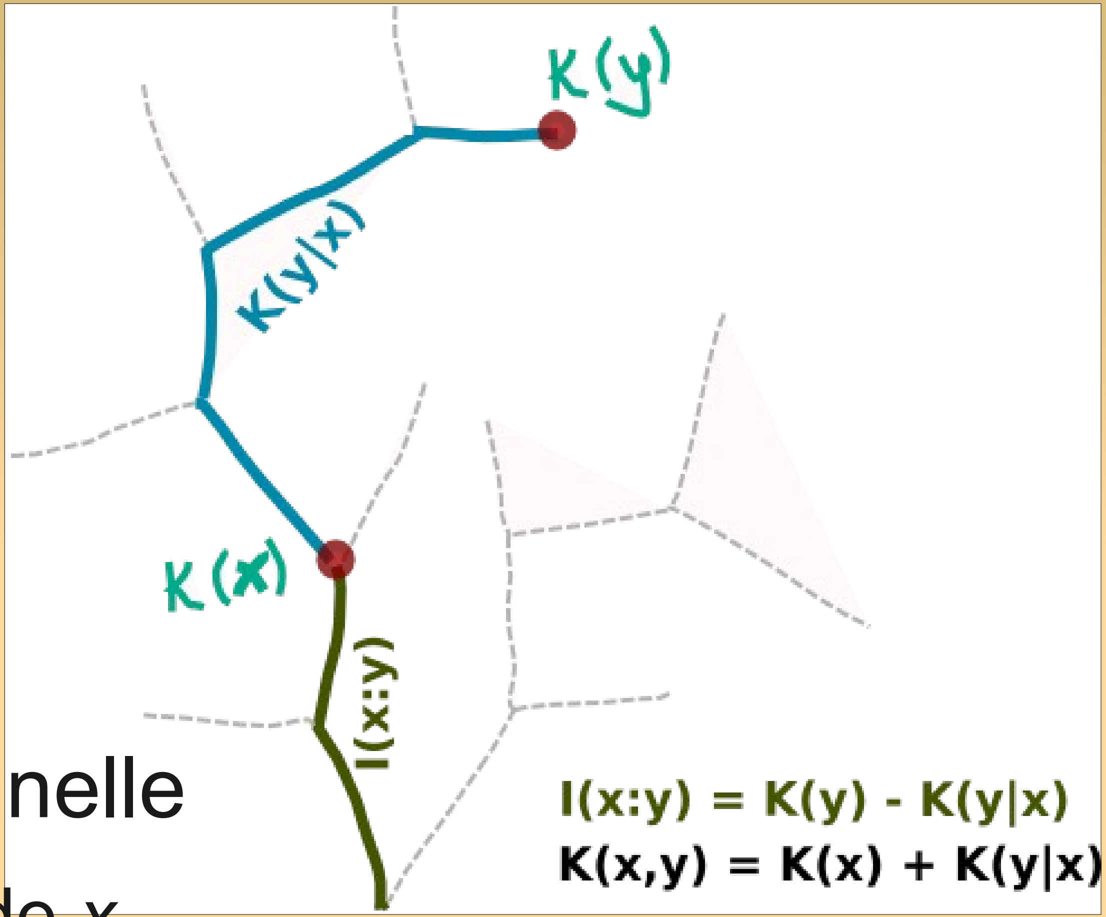
0010010000111111011010101000100010000010
1101000110000100011010011000100110000110
0110001010001011100000001101110000001110
0110100010010100100000001001001110000010
0010001010011001111100110001110100000000
0100000010111011111010100110001110110010
0111001101100100010010100010100101000000
1000011110011000111000110100000000100110
1110111101111110010101000110011011001111
0011010011101001000011000110110011000000
0101011000010100110110111110010010111111
0001010000110111010011111111000010011010
1011011010110110101010100011100001001001

Kolmogorov complexity

0010010000111111011010101000100010000 10
1101000110000100011
0110001010001011100
0110100010010100100
0010000101001100111 1
0100000010111011111 0
0111001101100100010
1000011110011000111
1110111110111110010 1
0011010011101001000
0101011000010100110
0001010000110111010
1011011010110110101010001110000010010001

Kolmogorov complexity

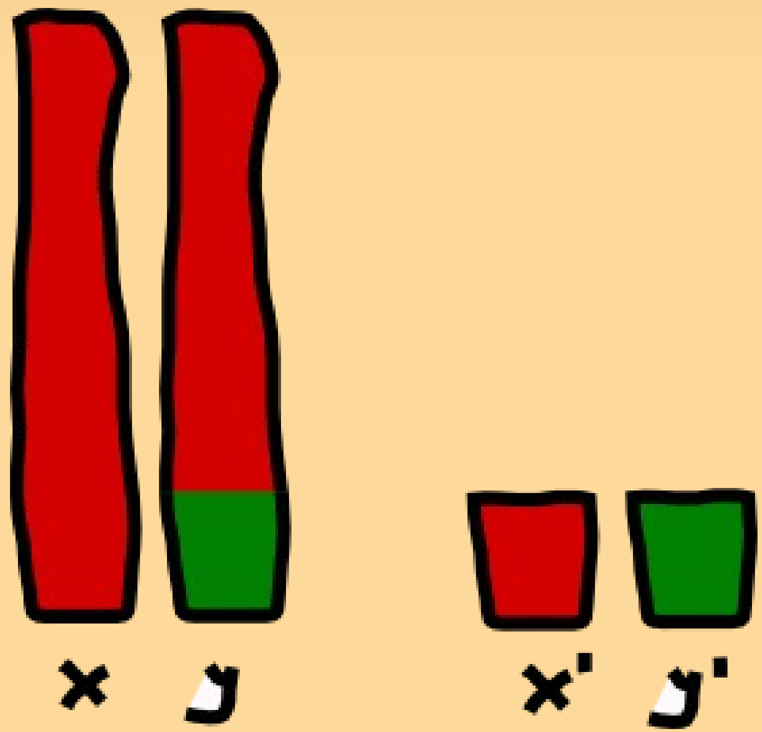
- Absolue
- Non-calculable
  - Mais approximable: Gzip, bzip2 etc.



- Complexité conditionnelle
  - *K(x|y)* la complexité de *x* si l'on a déjà *y* en entrée (≤ *K(x)*)
  - I(x:y) ≈ I(y:x)

Information distance

- E(x,y)= max {K(x|y), K(y|x)}
  - Le program qui transforme *x* en *y* et l'inverse
  - The largest transformation program "includes" the smallest (almost)
  - Absolue, minorise tout
- Normalization
  - Quelle paire est plus similaire en couleur ?
  - d(x,y) = K(y|x) / K(y)



Normalized compression distance

- Etant donne le compresseur *C* (ex. Bzip2)
  - Comme C(y|x) = C(x,y) – C(x), si C(y) > C(x)
  - $$NCD(x, y) = \frac{C(xy) - C(x)}{C(y)}$$
  -
  - On peut donc calculer des distances entre fichiers, génomes, romans, pièces musicales, en comprimant les objets séparément et ensemble
  - Algorithmes de clustérisation sans paramètres

Le compresseur doit être *normal*

- Un compresseur *C* est *normal* si :
  - Idempotence: C(xx) = C(x)
  - Monotonicité: C(xy) >= C(x)
  - Symmetrie: C(xy) = C(yx)
  - Distributivité: C(xy)+C(z) <= C(xz)+C(yz)
- Alors seulement la distance NCD est une metrique de similarité:
  - D(x,y) = 0 iff x = y; D(x,y) = D(y,x), et
  - D(x,y) <= D(x, z)+D(z,y) (triangle ineq)
  - Et contrainte de densité: $\sum_{y} 2^{-d(x,y)K(x)} \leqslant 1$

Pourquoi ces formules?

- De toute façon quand on veut approximer *K* on est en état de pèche
  - On ne sait pas si on approxime bien ou pas
- La compression peut donner des résultats intéressants
  - mais uniquement si le compresseur est (quasi)normal
- Chercher donc des compresseurs normaux

Normalized Google Distance

- Google comme compresseur
  - Pourquoi Google comprime : le code dérivé des probabilités G(x) = -log *p(x)* est minimal. Si hits(*y*)< hits(*x*):

$$NGD(x,y)=\frac{G(xy)-G(x)}{G(y)}$$

$$NGD(x,y)=\frac{\log hits(y)-\log hits(xy)}{\log N-\log hits(x)}$$

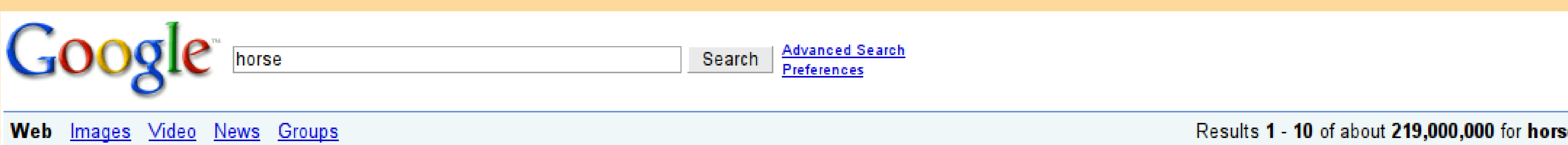
Google JSON API

http://ajax.googleapis.com/ajax/services/search/web?v=1.0&q=horse&rsz=small

{"responseData": {"results":[{"GsearchResultClass":"GwebSearch","unescapedUrl":"
http://en.wikipedia.org/wiki/Horse",
"url":"http://en.wikipedia.org/wiki/Horse",
"visibleUrl":"en.wikipedia.org",e: Your Guide to Equine Health
Care","titleNoFormatting":"The Horse: Your Guide to Equine Health
Care","content":"\u003cb\u003eHorse\u003c/b\u003e health news and veterinarian-
approved equine health care information from TheHorse.com. Learn more about basic
care, injuries, diseases, lameness, \u003cb\u003e...\u003c/b\u003e"}],

....

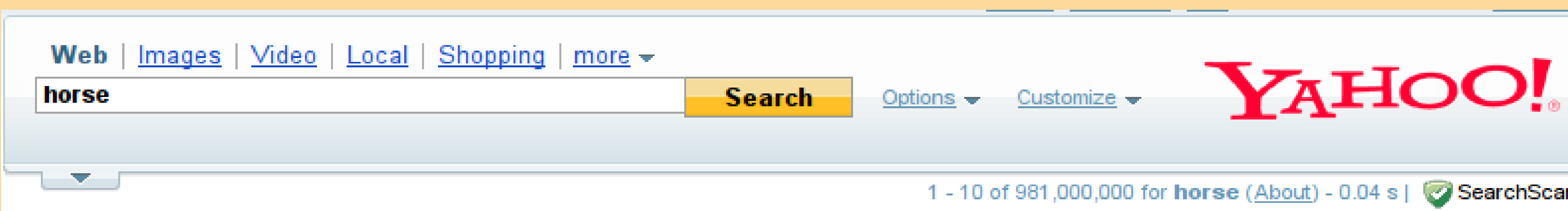
"cursor":{"pages":[{"start":"0","label":1},{"start":"4","label":2},
{"start":"8","label":3},{"start":"12","label":4},{"start":"16","label":5},
{"start":"20","label":6},{"start":"24","label":7},
{"start":"28","label":8}],**"estimatedResultCount":"27700000"**,"curren
tPageIndex":0,"moreResultsUrl":"http://www.google.com/search?
oe\u003dutf8\u0026ie\u003dutf8\u0026source\u003duds\u0026start\u003d0\u0026hl\u003d
fr\u0026q\u003dhorse"}}, "responseDetails": null, "responseStatus": 200}



Yahoo BOSS API

http://boss.yahooapis.com/ysearch/web/v1/horse?appid=...&format=xml (or json)

```
<ysearchresponse responsecode="200">
<nextpage>
/ysearch/web/v1/horse?count=10&appid=...&format=xml&start=10
</nextpage>
<resultset_web count="10" start="0"
totalhits="32651389" deephits="981000000">
....
```



Exemple : street - building

log(f('street')) = log2(134,000,000) = 26.9976577597819; g = f/N = 0.0067; G = log(1/g) = 7.22162318909168

log(f('building')) = log2(74,400,000) = 26.1487992855448; g = f/N = 0.00372; G = log(1/g) = 8.07048166332878

log(f('"street" "building"')) = log2(76,700,000) = 26.1927232419397; g = f/N = 0.003835; G = log(1/
= 8.02655770693388

(26.9976577597819 - 26.1927232419397) / (34.2192809488736 – 26.1487992855448)

NGD('street', 'building') = 0.0997381013204846

Exemple : street - slap

log(f('street')) = log2(134,000,000) = 26.9976577597819; g = f/N = 0.0067; G = log(1/g) = 7.22162318909168

log(f('slap')) = log2(3,700,000) = 21.8190938400658; g = f/N = 0.000185; G = log(1/g) = 12.4001871088079

log(f('"street" "slap"')) = log2(258,000) = 17.9770115400853; g = f/N = 1.29e-05; G = log(1/g) = 16.2422694087883

(26.9976577597819 - 17.9770115400853) / (34.2192809488736 – 21.8190938400658)

NGD('street', 'slap') = 0.727460492373477

Indexation de Wikipedia

- Lucene : outil Java d'indexation
  - Snowball English stemmer; wikipedia tokenizer
- Indexation
  - par paragraph (petite fenêtre de coccurence)
  - NGD à l'origine se fait sur Google par page
  - en.wikipedia : 18GB text
  - 8M pages
  - 40M paragraphs

Indexation de Wikipedia

- 7 millions terms
  - 7k avec freq > 10.000 (ex: kindergarten, basket)
  - 31k avec freq > 1000 (ex: radiocarbon, kryptonit)
  - 92k freq > 200 (ex: hölder, ipsilater, jolanda)
- Counting hits a posteriori is slow for lots of documents
- Solution: matrice de coocurrence pendant le parsing
  - Matrice de coocurrence doit rentrer en RAM
  - Optimisation : symmetrique, zero diag

Carte sémantique

- Calculer *toutes* les distances entre *tous* les mots (10.000)
- Pour chaque mot récupérer les voisins les plus proches
  - Mémoire sémantique: on peut retrouver les “voisins” d'un concept
- Difficile sur un vrai moteur de recherche public
  - Mais faisable sur son petit home-grown search engine

Exemples

- *HUNT*: prey, witch, deer, fish, hound, wild, predat, treasur, herd, trap, wildlif, dog, bounti, hike, lodg,
- *LEADERSHIP*:rite, resign, organiz, faction, skill, caucus, leader, membership, apostol,cabinet, coalit
- *FRANCE*:french, département, commune, pari, région, belgium, itali, comté, germani, inse, arrondiss
- *CHILDREN*:marri, husband, marriag, coupl, older, alon, spous, togeth, someon, household, individu
- *BABY*:pregnant, cry, gonna,infant, wanna, child, ain't, mama, sweet, tonight, doll, daddy, goodby, mother

Exemples (2)

- *ROAD*: junction, highway, terminus, intersect, rout, traffic, lane, motorway, bypass, parkway,
- *STREET*:avenu, downtown, boulevard, wall, corner, intersect, manhattan, neighborhood, coron, shop
- *MONSTER*: creatur, dungeon, beast, alien, horror, unleash, evil, summon, dragon, demon, loch.
- *SEVENTH* :eighth, sixth, ninth, fifth, tenth, eleventh, twelfth.
- *TERRY* :ron, bobbi, jimmi, ted, larri, jeff, ken
- *VICEROY*:granada, marquess, napl, peru, spaniard, río

Mais... (words without meaning)

- *WHICH (freq: 2M)*: there, been, had, into, also, alon, some, most, them, but, onli, howev
- *BAD (200k)*: faith, isn't, realli, doesn't, sure, can't, agre, someon, thing, obvious,
- *GOOD (500k)*: think, don't, i'm, thing, realli, look, faith, seem, sure, veri, i'v, isn't, know, say, get
  - *Mais la fréquence n'est pas tout: PERFORM (lui aussi 500k)*:concert, theatr, stage, audienc, orchestra, solo, ensembl, soloist, sing, tour, repertoir, festiv, theater, singer, danc, grammi, musician

LSA vs. NGD: Cosinus vs. K(x|y)

- Ex (session Octave):

```
$ x = 50 * rand(1,300) - 25
$ y = 1 + x
$ x * y'  / (norm(x) * norm(y))
0.99753
$ y = x .^ 2
$ x * y'  / (norm(x) * norm(y))
0.097678
```

- (une transformation mathématiquement simple peut mener à des différences structurales importantes)

Bibliographie

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