Introduction to page Rank
Axes of improvement
What's next ?

Présentation projet de recherche

Théodore CHAPUIS-CHKAIBAN, Ghita CHEMIA, Paul
LIEUTIER, Hugo SERVANT, Victor SANSAC

Ecole CentraleSupélec

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Outline

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Main ideas
Quantum Page Rank
Complexity

Page Rank

- Principe : étudier la centralité du réseau internet
- Lien avec les algorithmes quantiques : le déplacement de l'utilisateur correspond à une marche aléatoire sur le graphe du web selon un processus de Markov
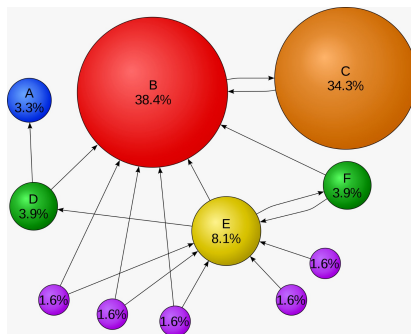

FIGURE 1 – Exemple de Graphe sur lequel fonctionne le Page Rank.

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Application

Une seule application réelle à l'heure actuelle :

- La classification des pages internet qui repose sur le nombre de pages qui contiennent un lien vers une page donnée.
- Il en découle un indice variant entre 1 et 10

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Quantum Page Rank

Google Page Rank

- Uses Grover search
- Uses Markovian chain search
- Quantum walk $\rightarrow$ matrix reduction ; SVD

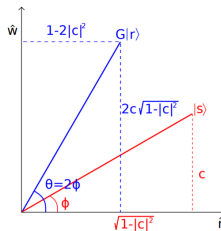FIGURE 2 – Grover search is used to compute the page rank using the Perron-Frobenius Theorem.

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Complexity calculation

Theorem 1

The average complexity of these methods is $\sqrt{N}$ where N is the size of the imput data set.

Theorem 2

This complexity is the minimum one can reach when searching for an element in a predefined set (Grover Search).

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What about machine learning ?
How do quantum computers proceed the information ?

Complexity enhancement

- To improve the complexity, we have to drop the Grover Algorithm
- How can we improve the complexity ? Some quantum algorithms can reach a complexity of $log(N)$ in some cases.
- The Quantum Fourier transform is one example

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Quantum Fourier Transform

- What is the link between the Quantum Fourier Transform and the PageRank algorithm ?
- What about using wavelets to try optimise the performances ? (see "Dimension Reduction Using Quantum Wavelet Transform on a High-Performance Reconfigurable Computer" by Naveed Mahmud and Esam El-Araby)

Assumption

Since PageRank involves methods of matrix reduction (via SVD), Quantum Fourier Transform methods for frequencies analytics can be applied to this problem. (see "A SHORT-GRAPH FOURIER TRANSFORM VIA PERSONALIZED PAGERANK VECTORS" by Mariano Tepper and Guillermo Sapiro)

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Machine learning methods to broaden the field of applications

- Machine learning involves methods used in PageRank to classify data
- Complexity in $log(n)$ (see "Quantum support vector machine for big data classification" by Patrick Rebentrost and all)
- May be interesting to establish a parallel between the two methods.

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How do quantum computers proceed the information ?

- Quantum grover search exhibit a better understanding of webpages by allowing more importance to secondary hubs
- Why is there a difference between classical and quantum computers ?
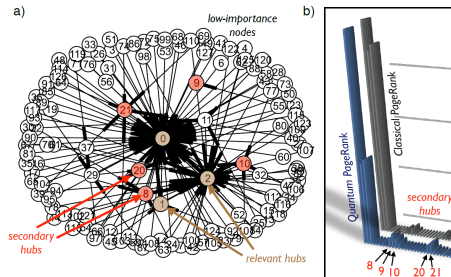
FIGURE 3 – Quantum algorithms resolves secondary hubs better than the classical ones.

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Work on the classical PageRank
Overview of the forthcoming work

Code Classical PageRank

FIGURE 4 – Python Code for the Classical PageRank

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Work on the classical PageRank
Overview of the forthcoming work

What's next ?

1. Code the classical and quantum versions of PageRank using Grover Search and the Perron Frobenius Theorem
2. Find an equivalent for the Fourier transform and implement it
3. Adapt it to the Wavelet method
4. Quantify the economy made in calculations
5. Adapt the algorithm to Big Data issues involving reduction of dimension