

# Groverize Monotone Local Search. (Short Note)

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## 1 Todo.

1. Write the table (sage script).
2. Add definitions. Problem description.
3. Complete the 'proof'.
4. Prove lower bound.

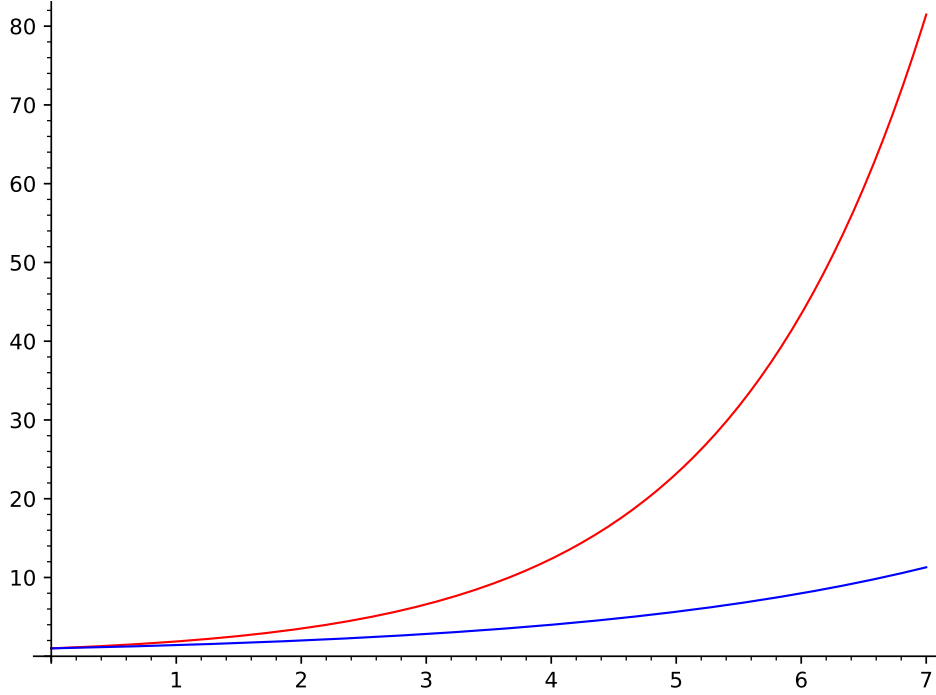
## 2 Introduction.

We follow the study of [Fom+15], who relate between the parametrized complexity to the general average case complexity. Crudely put, they shown that for particular wide range of **NP** hard problems, a solution which run exponentially at some complexity parameter, for example the tree-width of a graph, can be used to derive a batter than bruteforce solution for the general problem. We continue their work by plugin the Grover search [Gro96] routine instead the original sampling process.

$$\begin{aligned} \sum_{k' \leq k} \frac{1}{\sqrt{p(k')}} \cdot c^{k'-t} N^{\mathcal{O}(1)} &\leq \max_{k' \leq k} \left( \frac{\binom{n-|X|}{t}}{\binom{k'}{t}} \right)^{\frac{1}{2}} \cdot c^{k'-t} N^{\mathcal{O}(1)} = \\ \left( \max_{k' \leq k} \frac{\binom{n-|X|}{t}}{\binom{k'}{t}} \cdot c^{2(k'-t)} \right)^{\frac{1}{2}} N^{\mathcal{O}(1)} &= \left( \max_{k \leq n-|X|} \frac{\binom{n-|X|}{t}}{\binom{k}{t}} \right)^{\frac{1}{2}} \cdot c^{2(k-t)} N^{\mathcal{O}(1)} \leq \\ \Rightarrow \left( 2 - \frac{1}{c^2} \right)^{\frac{n-|X|}{2}} N^{\mathcal{O}(1)} \end{aligned}$$

Problem Name	Parameterized	Groverize	New bound	Previous Bound
FEEDBACK VERTEX SET	$3^k$ (r) [Cyg+11]	$1.37^k$	$1.6667^n$ (r)	
FEEDBACK VERTEX SET	$3.592^k$ [KP14]	$1.39^k$	$1.7217^n$	$1.7347^n$ [FTV15]
SUBSET FEEDBACK VERTEX SET	$4^k$ [Wahlstrom14]	$1.39^k$	$1.7500^n$	$1.8638^n$ [Fom+14]

Table 1: Summary of known and new results for different optimization problems. NPR means that we are not aware of any previous algorithms faster than brute-force. All bounds suppress factors polynomial in the input size  $N$ . The algorithms in the first row are randomized (r).



## References

- [Gro96] Lov K. Grover. *A fast quantum mechanical algorithm for database search*. 1996. arXiv: [quant-ph/9605043](https://arxiv.org/abs/quant-ph/9605043) [quant-ph].
- [Cyg+11] Marek Cygan et al. “Solving connectivity problems parameterized by treewidth in single exponential time (extended abstract)”. In: *2011 IEEE 52nd Annual Symposium on Foundations of Computer Science—FOCS 2011*. IEEE Computer Soc., Los Alamitos, CA, 2011, pp. 150–159. DOI: [10.1109/FOCS.2011.23](https://doi.org/10.1109/FOCS.2011.23). URL: <https://doi.org/10.1109/FOCS.2011.23>.
- [Fom+14] Fedor V. Fomin et al. “Enumerating minimal subset feedback vertex sets”. In: *Algorithmica* 69.1 (2014), pp. 216–231. ISSN: 0178-4617. DOI: [10.1007/s00453-012-9731-6](https://doi.org/10.1007/s00453-012-9731-6). URL: <https://doi.org/10.1007/s00453-012-9731-6>.
- [KP14] Tomasz Kociumaka and Marcin Pilipczuk. “Faster deterministic Feedback Vertex Set”. In: *Inform. Process. Lett.* 114.10 (2014), pp. 556–560. ISSN: 0020-0190. DOI: [10.1016/j.ipl.2014.05.001](https://doi.org/10.1016/j.ipl.2014.05.001). URL: <https://doi.org/10.1016/j.ipl.2014.05.001>.
- [FTV15] Fedor V. Fomin, Ioan Todinca, and Yngve Villanger. “Large induced subgraphs via triangulations and CMSO”. In: *SIAM J. Comput.* 44.1 (2015), pp. 54–87. ISSN: 0097-5397. DOI: [10.1137/140964801](https://doi.org/10.1137/140964801). URL: <https://doi.org/10.1137/140964801>.

- [Fom+15] Fedor V. Fomin et al. *Exact Algorithms via Monotone Local Search*. 2015. arXiv: [1512.01621](#) [[cs.DS](#)].