Edge Omission Techniques for Visualization of Dense Directed Graphs

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ABSTRACT
To be added later.

ACM Classification Keywords
H.5.2 User Interfaces: Graphical user interfaces (GUI)

Author Keywords
Lossy compression; graph visualization; hardness reductions.

INTRODUCTION
In 1971 Stephen Cook showed that satisfiability (SAT) is an NP-complete problem. In 1972, Richard Karp showed that twenty one other problems are also NP-complete by a polynomial time reduction to SAT. Unlike SAT, the problems that Karp showed "hard" came from a variety of disciplines and often had natural descriptions. Encouraged by Karp's results, there was a flurry of research showing that many other problems in many other fields are also NP-Hard.

In 1979 Michael Garey and David Johnson publish *Computer and Intractability: a Guild to the Theory of* NP*-Completeness* [3] in which they collected more than 300 NP-Completeness proofs both from the literature and from their own research. Even today, this seminal work is often the goto reference manual for computer scientists trying to prove that their particular problem is NP-hard.

Enthusiasm for such reductions have diminished since then due to the difficulty in proving or disproving $\mathsf{P} = \mathsf{NP}$ and the shifting interest of the field. Even so, many problems that computer scientists encounter today are still NP-Hard. Showing this to be the case is a useful first step for legitimizing the use of approximation algorithms and heuristic approaches.

The strategy for proving that a tricky decision problem B is NP-Hard has not change since Karp's time. One must find an NP-complete problem A and show a polynomial reduction $A \leq_p B$ such that YES-instance of A map to YES-instance of B and NO-instances of A map to NO-instance of B. To this end it is often useful to have a wide variety of problems which may serve as A. Unfortunately, most collections of NP-Complete problems have not been kept up-to-date and are uniformly arranged in a list-like structure. This layout makes it difficult to see relationship between problems in different fields with similar reductions.

We propose updating the way this collection of NP-Hard problems is represented. Using techniques for visualizing dense directed graphs, we hope to display these reduction more naturally as a graph. Since some problems such as 3SAT, partition, and vertex cover are often used for reductions, they may appear as nodes with high degree in the graph. Thus it maybe necessary to *delete* (in addition to compress) edges to make the overall representation readable to the user.

We will investigate how this *lossy* compression impacts the usability of the graph and if the proximity and color of nodes can be used to replace or imply adjacency relationships.

RELATED WORK
In addition to the book by Garey and Johnson, the Wikipedia page (https://en.wikipedia.org/wiki/List_of_NP-complete_problems) and *A compendium of* NP *optimization problems* (http://www.nada.kth.se/~viggo/wwwcompendium/) edited by Peirluigi Crescenzi and Viggo Kann represent typical collections of NP-complete problems. Of the three, the Wikipedia page is the most active, with discussion entries as recent as 2016, but it is also the least comprehensive. Problems are listed on one page and are grouped under a few general headings. Clicking on a problem brings the user to the relevant Wikipedia page which can range wildly in the quantity and quality of the content. The *Compendium* was last edited in 2005, but organizes the problems in a more thorough manner. The landing page features a comprehensive list of categories and sub-categories. Clicking on a category or subcategory brings the user to the list of associated problem. Each problem includes a few standard descriptors including: instance, solution, and comments.

Previous work in the HCI literature we plan to review include:

1. *On finding graph clustering with maximum modularity.* [1]
2. *Edge Compression Techniques for Visualization of Dense Directed Graphs.* [2]
3. *Drawing graphs using modular decomposition.* [5]
4. *Linear-time modular decomposition of directed graphs.* [4]

METHOD
We hope to present the collection of NP-Hard problems as a graph on an interactive web-page. Problems will be represented as nodes. The color, size, and shape of a node will be used to convey the problem's category, frequency of use, and other features. The proximity of the problem will be used

to represent the *reduction* relationship. Further, we hope to incorporate a robust search function to find relevant problems based on the key words used in its statement and description.

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