The Name of the Title is Hope

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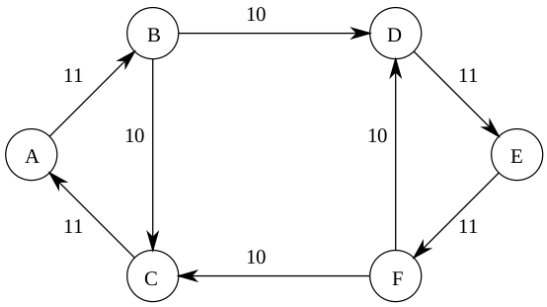
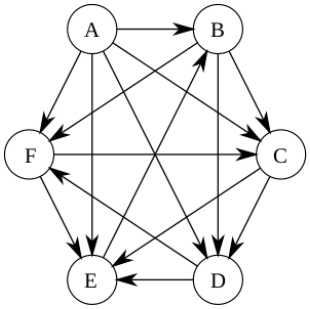


(a) A three cycle graph which demonstrates that greedily selecting the minimum weighted edge will not provide the minimum feedback arc set.



(b) A four cycle graph where each cycle depends on the edge (E,B).

ABSTRACT

Abstract here

KEYWORDS

datasets, neural networks, gaze detection, text tagging

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1 INTRODUCTION

The minimum feedback arc set problem is a canonical NP-Complete problem given by **?**]. Worse still, the problem is APX-hard yet finding the minimum feedback arc set of a directed graph is desirable for many domains: such as certain rank-choice voting systems, tournament ranking systems, and dependency graphs in general.

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Solutions to the minimum feedback arc set problem are commonly implemented in widely used graph libraries yet all suffer from a distinct flaw. While each implementation provides a solution, the implementations only do so without allowing the user to inspect intermediate steps; which might contain useful domain information. For example, the graph Figure 1b displays a directed graph which encodes a single win tournament system. Each vertex is a player and each edge encodes a win over a contestant, for example we see that player E beat contestant B. Observe that the Figure 1b contains cycles which implies that there is not a linear ordering amongst the contestants of the tournament, and so any ranking of the contestants would violate a win of one contestant over another. Removing the minimum feedback arc set would remove the cycles, which yields a linear order in the tournament that violates the fewest number of wins. In this example, intermediate results are edges which compose the minimum feedback arc set, thus if one had access to the intermediate results one might choose to rematch the opponents rather than remove the win. Crucially, the result of the rematch may change the final minimum feedback arc set. Such a procedure could therefore increase the confidence in the results of the tournament.

To allow for *inspectable incrementality* we propose a novel direction in solving the minimum feedback arc set problem based on recent advances in satisfiability solving (SAT) and satisfiability-modulo theories (SMT) solving. Our approach is to utilize an SMT solver to detect cycles and minimize the weight of the feedback arc set. Incrementality in this approach is given through use of an *incremental* SMT solver and generation of *unsatisfiable cores*. A minimum unsatisfiable core is the minimum set of clauses in a SAT or SMT formula which prevent a SAT or SMT solver run from finding a satisfiable assignment. An incremental solver provides the end-user the ability to add or remove constraints and thereby direct the solver during runtime. Incrementality in our approach is crucial as it the end-user decision points to interact with the solution process. Thus, an end-user might observe a unsatisfiable core which corresponds to a cycle and decide to resample *only* those edges.

but is it novel?

The approach has benefits . . .

We make the following contributions:

(1) Gadgets
(2) Evaluation of unsatisfiable cores for this problem domain
(3) empirical evaluation of this novel method

again, is it novel?

2 BACKGROUND AND RELATED WORK

We grounded . . .

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3 GADGETS

Dem ga**gd**ets

4 CASE STUDIES

We did it! Once, twice probably not three times!

5 RESULTS AND DISCUSSION

It was good enough to graduate