Comparing branch-and-bound, cutting planes, and branch-and-cut

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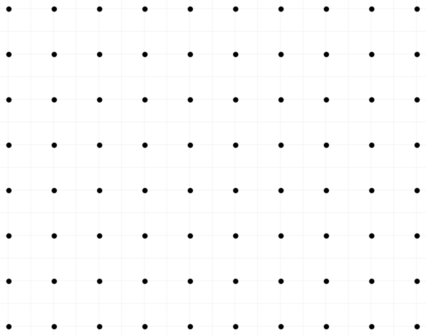
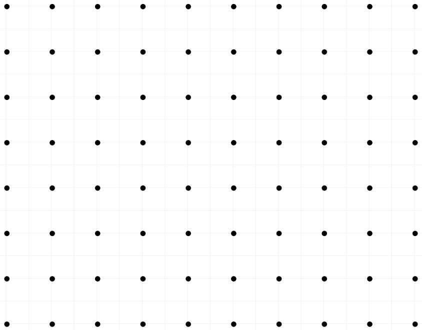
Branch-and-bound

Branch-and-bound



Cutting planes



Branch-and-cut

Branch-and-bound: simple exponential examples

Jeroslow (1973); Dadush, Tiwari (2020)

Full strong branching

Full strong branching: something not surprising

Dey, Dubey, Molinaro, Shah (2024)

Theorem

For some instances of the minimum vertex-cover problem, "natural" variable selection rules produce branch-and-bounds trees that are $2^{0.75n}$ *times larger than the tree generated by the full strong branching rule.*

Full strong branching: something surprising

Dey, Dubey, Molinaro, Shah (2024)

Theorem

There are 0/1 IP instances with $2n$ variables that admit a branch-and-bound tree of size $4n+1$, but such that any rule that only branches on fractional variables (including full strong branching) produces a tree of size $\geq 2^n$.

Full strong branching: computational evaluation

Dey, Dubey, Molinaro, Shah (2024)

(Non)monotonicity of branch-and-bound

Branch-and-bound can be (heavily!) non-monotonic

Shah, Dey, Molinaro (2025)

Theorem

All rules that branch only on fractional variables are non-monotonic.

Branch-and-bound can be (heavily!) non-monotonic

Shah, Dey, Molinaro (2025)

Theorem

All rules that branch only on fractional variables are non-monotonic.

Theorem

Under the full strong branching rule, adding a single cut can increase the size of the branch-and-bound tree exponentially.

Non-monotonicity of branch-and-bound: computational evaluation

Shah, Dey, Molinaro (2025)

Comparison between branch-and-bound and cutting planes

Basu, Conforti, Di Summa, Jiang (2022; 2023)

Comparison between branch-and-bound and cutting planes

Basu, Conforti, Di Summa, Jiang (2022; 2023)

variable disjunctions		general split disjunctions	
0/1 sets	general sets	0/1 sets	general sets

Comparison between branch-and-bound and cutting planes

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variable disjunctions		general split disjunctions	
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CP $\leq$ BB			

Comparison between branch-and-bound and cutting planes

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variable disjunctions		general split disjunctions	
0/1 sets	general sets	0/1 sets	general sets
CP $\leq$ BB CP $poly(n)$ vs BB $exp(n)$			

Comparison between branch-and-bound and cutting planes

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Comparison between branch-and-bound and cutting planes

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variable disjunctions		general split disjunctions	
0/1 sets	general sets	0/1 sets	general sets
CP $\leq$ BB CP $poly(n)$ vs BB $exp(n)$	BB $O(1)$ vs CP ∞ CP $poly(n)$ vs BB $exp(n)$		

Comparison between branch-and-bound and cutting planes

Basu, Conforti, Di Summa, Jiang (2022; 2023)

variable disjunctions		general split disjunctions	
0/1 sets	general sets	0/1 sets	general sets
CP $\leq$ BB CP $poly(n)$ vs BB $exp(n)$	BB $O(1)$ vs CP ∞ CP $poly(n)$ vs BB $exp(n)$	BB $\leq 4{\cdot}$CP	BB $\leq 4{\cdot}$CP

Comparison between branch-and-bound and cutting planes

Basu, Conforti, Di Summa, Jiang (2022; 2023)

variable disjunctions		general split disjunctions	
0/1 sets	general sets	0/1 sets	general sets
CP $\leq$ BB	BB $O(1)$ vs CP ∞	BB $\leq 4 \cdot$CP	BB $\leq 4 \cdot$CP
CP $poly(n)$ vs BB $exp(n)$	CP $poly(n)$ vs BB $exp(n)$		BB $O(1)$ vs CP $poly(data)$

Comparison between branch-and-bound and cutting planes

Basu, Conforti, Di Summa, Jiang (2022; 2023)

variable disjunctions		general split disjunctions	
0/1 sets	general sets	0/1 sets	general sets
CP $\leq$ BB	BB $O(1)$ vs CP ∞	BB $\leq 4 \cdot$CP	BB $\leq 4 \cdot$CP
CP $poly(n)$ vs BB $exp(n)$	CP $poly(n)$ vs BB $exp(n)$	?	BB $O(1)$ vs CP $poly(data)$

Superiority of branch-and-cut

Basu, Conforti, Di Summa, Jiang (2022)

Superiority of branch-and-cut

Basu, Conforti, Di Summa, Jiang (2022)

Theorem

Given a complementary pair of BB and CP schemes, there are instances that admit polynomial-size branch-and-cut trees but only exponential-size BB trees and CP proofs.