Computational Social Choice (Comsoc) and Computational Complexity: BFFs? (Best Friends? Forever?)

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-What are these areas?

Used to represent the fields (and their practitioners, classes, structures, etc.)
The Key Point: There has been a two-way street of interaction, and both areas have benefitted from it.

- Thank you!
- help
- No, thank you!
- help
- This talk's focus!
  1. Populating Lonely Classes
  2. Using Lonely Tools

Psst... and you and you too, SAT solvers & planning &...
Make It a Party: Populating Lonely Complexity Classes

The polynomial hierarchy level capturing parallel access to \( \text{NP} \).

\[ \Theta_2^P = \text{P}^{\text{NP}} \]

\( L \in \text{P}^{\text{NP}} \) means:

- \( x \in L \) or
- \( x \notin L \)

\( \text{P}^{\text{NP}} \) is important in complexity:

- If \( E \) is sparse \( \text{NP} \)-complete set then \( \text{PH} = \text{P}^{\text{NP}} \)
- Many characterizations: \( \text{P}^{\text{NP}} = \text{L}^{\text{NP}} = \text{P}^{\text{NP} \circ (\log n)^2} = \text{L}^{\text{NP}} = ... \)

\( \text{P}^{\text{NP}} \neq \text{P}^{\text{NP}} \iff \text{NP} \) can "manufacture randomness"

... but ...

That "but" sounds ominous... I may not like where this is going...
A Party with all $P_{NP}$'s Natural Complete Sets (Before!):

yummy food!
NICE MUSIC!
A Party with all \( P^{NP}_{11} \)’s Natural Complete Sets (Before!):

- \( P^{NP}_{11} \) (P11):
  - No one! arghhh!

- \( P^{NP}_{11} \) (P11):
  - We feel your pain!

- Table:
  - Yummy food!
  - Nice music!
Make It a Party: Populating Lonely Complexity Classes

Woo! hoo!

Boogie! on!

All our winner problems are PNP-complete.... Conga-line time, Cha!

Kement Elections

We're coming too!

1878 1997

Dedason Elections

YOUNG ELECTIONS

We're coming too!

Yummy food! Nice music!
Populating Other Lonely Complexity Classes

I too found my first natural complete problem in COMSOC!

Online 3-candidate Veto elections' WCM problem

Make that 4-candidate and it becomes a new complete problem for me!

Many other classes have had their collection of natural complete problems expanded and enriched by:

\[ \text{NP, P, PP, } \text{NP, NPP, PP} \text{, and more.} \]

(for this by work on planning)
Lonely Tools? Machinery & notions find fertile ground in

Decision vs. Search

A solution

(satisfying assignment, manipulation, etc.)

exists.

} same or different complexity?

SAT: same! \( \equiv \)

lots: same!

\( \exists \) potential tool (1976) to separate search from decision on natural domains...., then.... tick, tock.... tick, tock.... 36 years....., then...
Fertile Ground for Lonely Tools

Unless integer factoring is easy, for \( \frac{1}{2} \) the std. manipulative electoral attack types \( \exists \) p-time-winner election system \( \exists \) decision is easy but search is not. Key machinery: 1970s!

By a completely different collection of 1970s complexity machinery, extremely repurposed, the search-failure rate is essentially as frequent as that of (any heuristic for) integer factoring.
Fertile Ground: Other Cases

Was the last slide a one-off? No:

AAAI-17: Both decision-vs.-search behavior types just presented (shearing apart of complexity, and "frequency-completeness") also can be shown for backbones of formulas (relevant to SAT solvers).

Many other notions & machinery from \( \mathcal{T} \) found new, fresh applications in the study of \( \mathcal{T} \):

- the join operator
- dichotomy
- alternation
- ...
Conclusions

- \( J \) and \( T \) have helped each other tremendously.
  - A true 2-way street.

- To continue and improve the synergy: Both areas should remain—and be ever more—open to seeking out and working w/those from the other.

- Ph.D. programs should encourage and create young researchers who are simultaneously expert in both areas.

These will allow advances far beyond even those already from this wonderful friendship.

BFFs? Yes, BFFs!