Untactical Unruly

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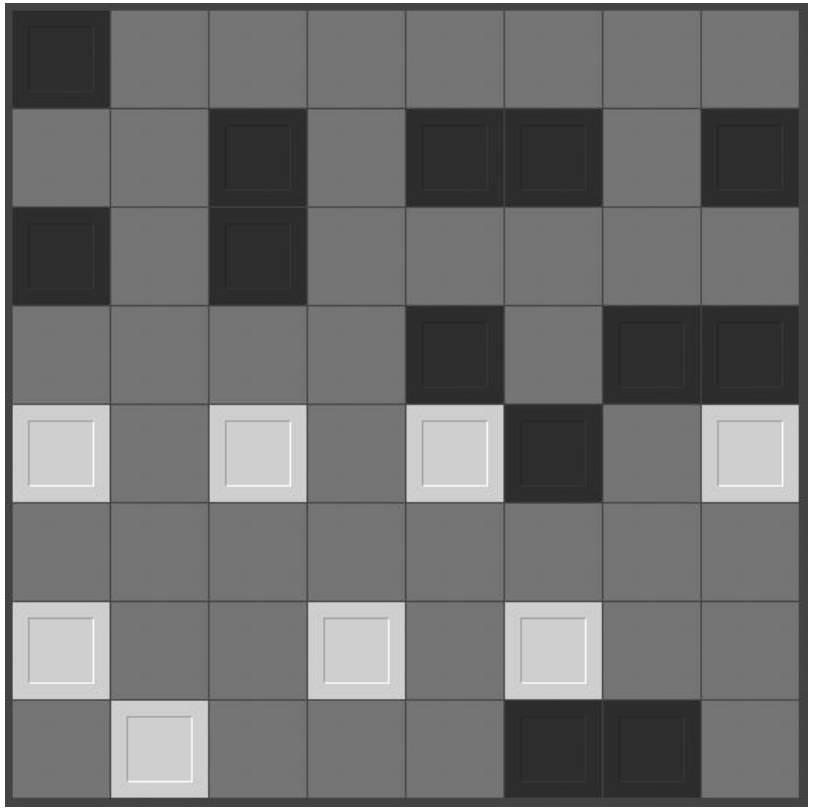
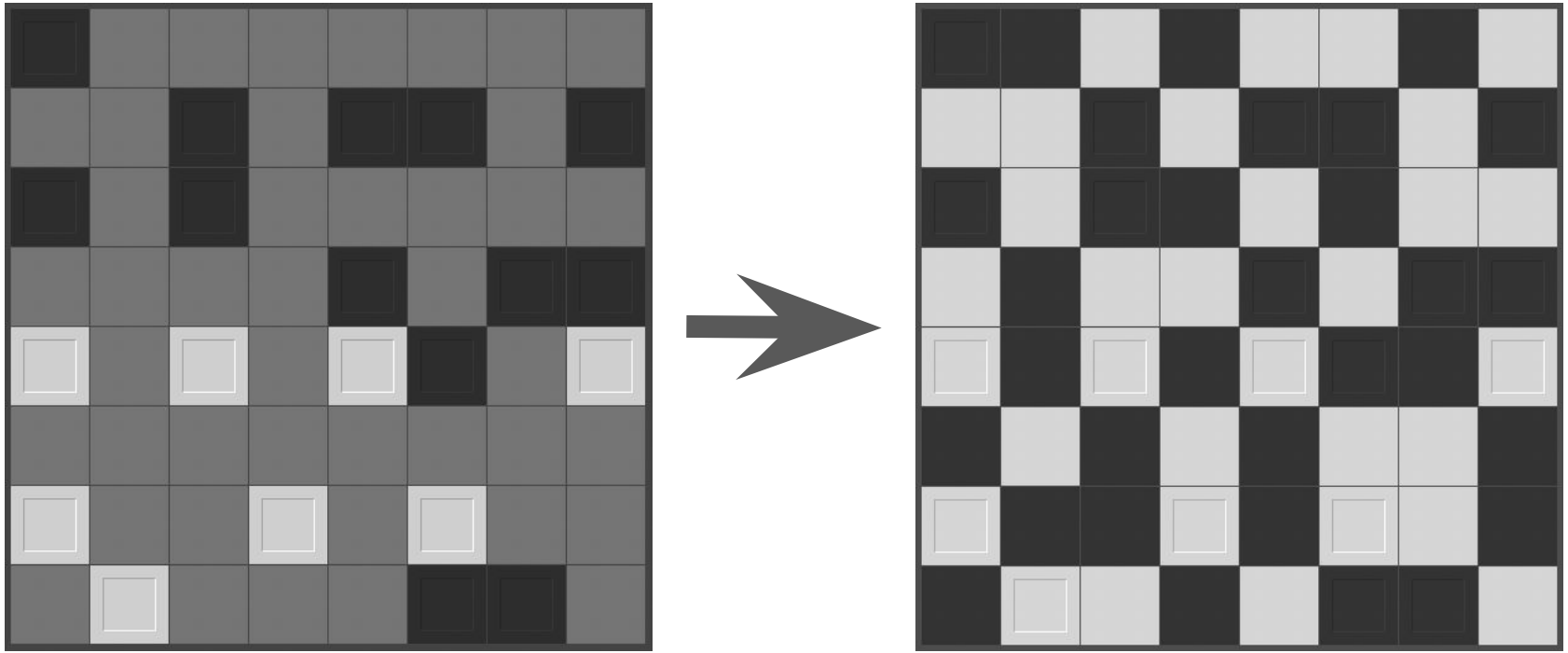
Unruly

Also known as

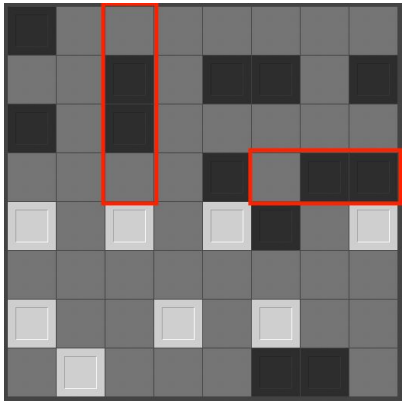
- Tohu wa Vohu
- Takuzu
- Binairo
- Binary Puzzles
- Binoxxo
- Sudoku Binary
- …



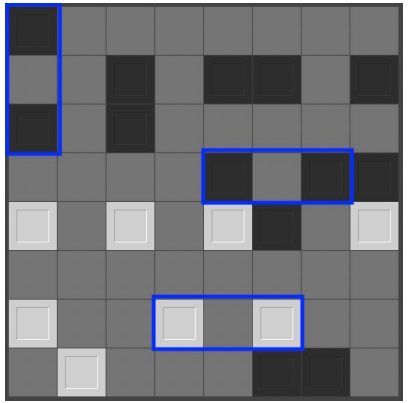


Solving tactics

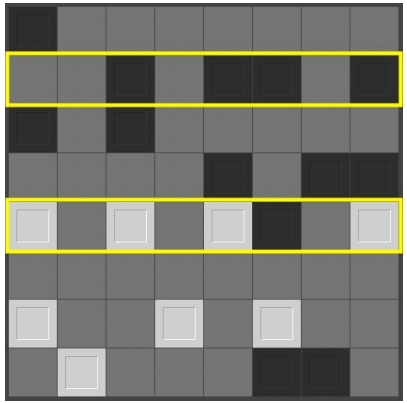
Endcaps



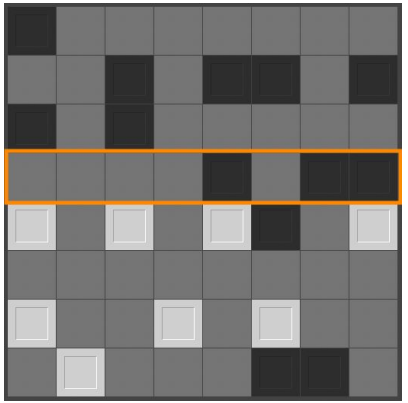
Gaps



n



n-1



Questions

1. Are these tactics always enough?
2. If not, is there a set of tactics which would be?

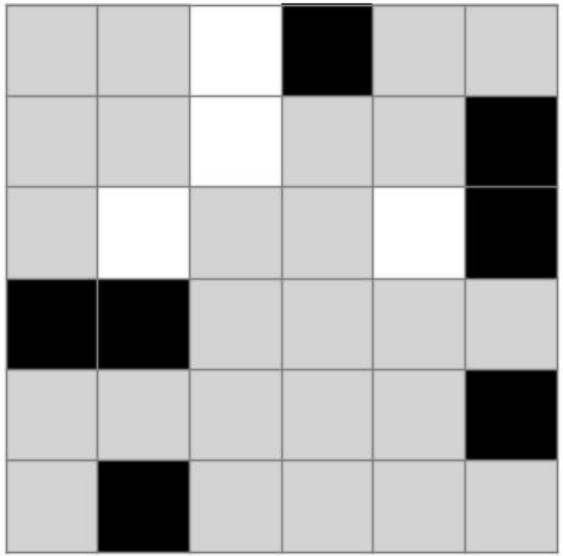
Are the tactics enough?

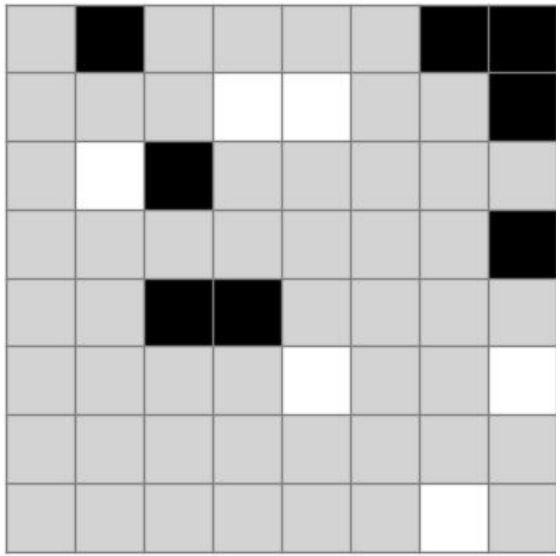
Yes, for a really boring reason

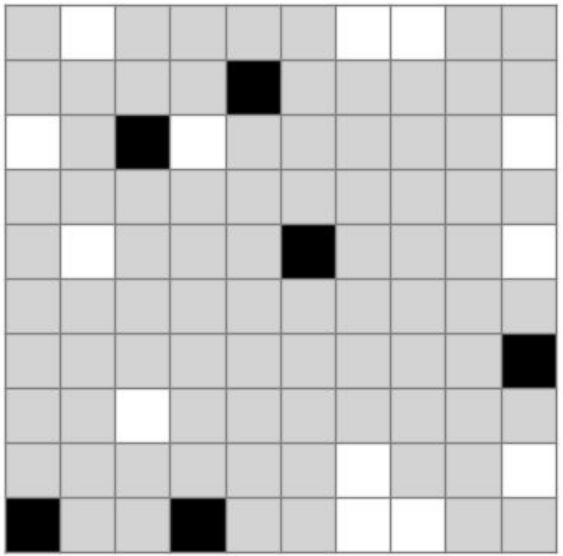
```
static int unruly_solve_game(game_state *state,
                             struct unruly_scratch *scratch, int diff)
{
    int done, maxdiff = -1;

    while (true) {
        done = 0;

        /* Check for impending 3's */
        done += unruly_solver_check_all_threes(state, scratch);

        /* Keep using the simpler techniques while they produce results */
        if (done) {
            if (maxdiff < DIFF_TRIVIAL)
                maxdiff = DIFF_TRIVIAL;
            continue;
        }

        /* Check for rows with only one unfilled square */
        done += unruly_solver_check_all_single_gap(state, scratch);

        if (done) {
            if (maxdiff < DIFF_TRIVIAL)
                maxdiff = DIFF_TRIVIAL;
            continue;
        }

        /* Easy techniques */
        if (diff < DIFF_EASY)
            break;

        /* Check for completed rows */
        done += unruly_solver_check_all_complete_nums(state, scratch);

        if (done) {
            if (maxdiff < DIFF_EASY)
                maxdiff = DIFF_EASY;
            continue;
        }

        /* Normal techniques */
        if (diff < DIFF_NORMAL)
            break;

        /* Check for nearly completed rows */
        done += unruly_solver_check_all_near_complete(state, scratch);

        if (done) {
            if (maxdiff < DIFF_NORMAL)
                maxdiff = DIFF_NORMAL;
            continue;
        }

        break;
    }
    return maxdiff;
}
```

Are the tactics enough?

No!







Is there a set of tactics that would always be enough?

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- No backtracking!

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- No backtracking!
- Implies *polynomial time*

P vs NP

P: Can find a solution efficiently

NP: Can check a solution efficiently

P vs NP

P: Can find a solution efficiently

NP: Can check a solution efficiently

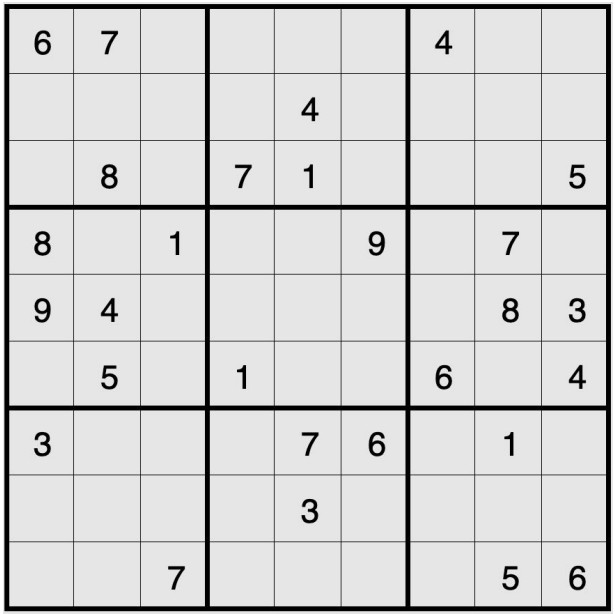
Does P = NP?

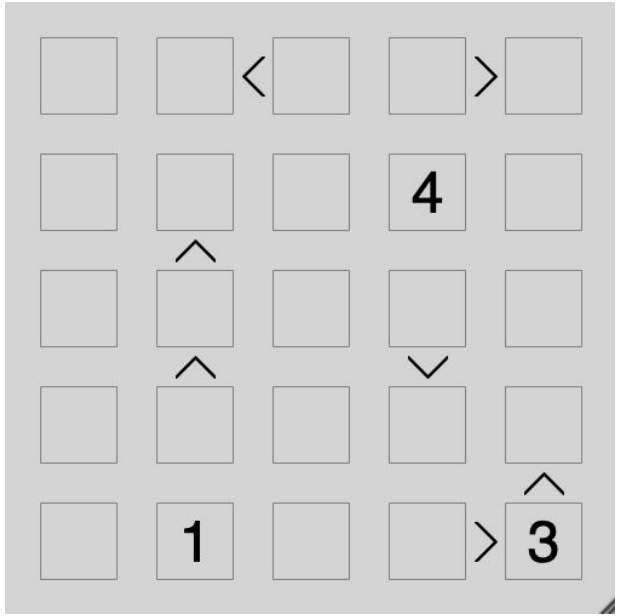
NP-completeness

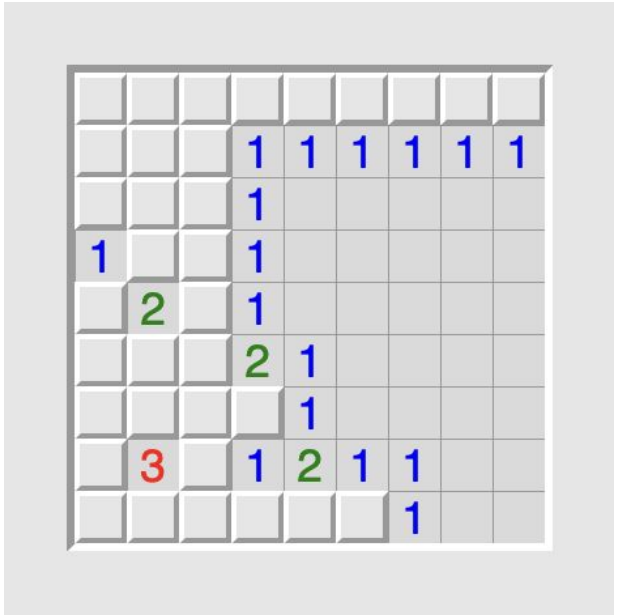
Problems in NP into which *any other problem in NP* can be translated

- Graph colouring
- Boolean satisfiability
- Travelling Salesman
- Bin-packing
- …

NP-completeness







Plan

Any NP problem $\leq_p$ SAT

$\leq_p$ 3SAT

$\leq_p$ Planar 3SAT

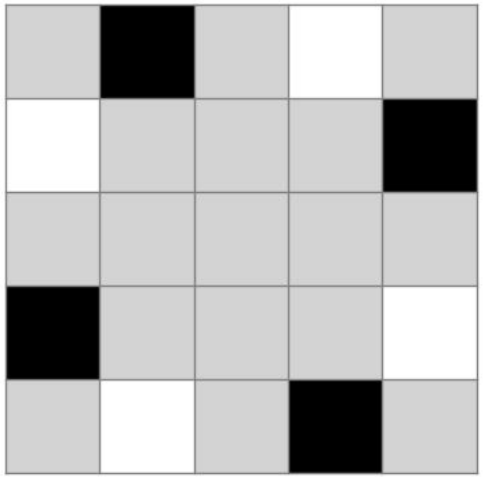
$\leq_p$ Unruly? ← This is the bit we have to prove

Logic in Unruly

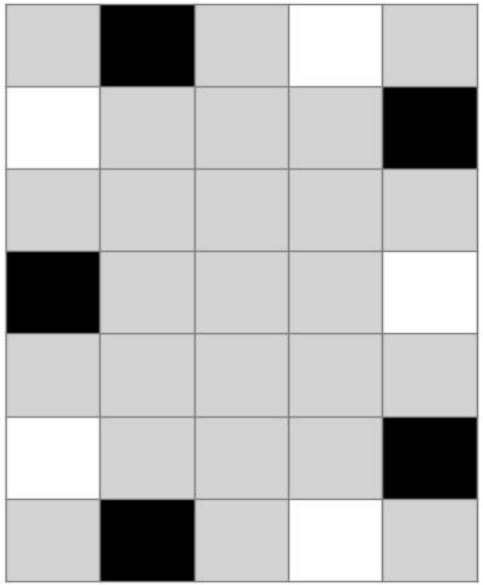
y if x

y only if x

Logic in Unruly



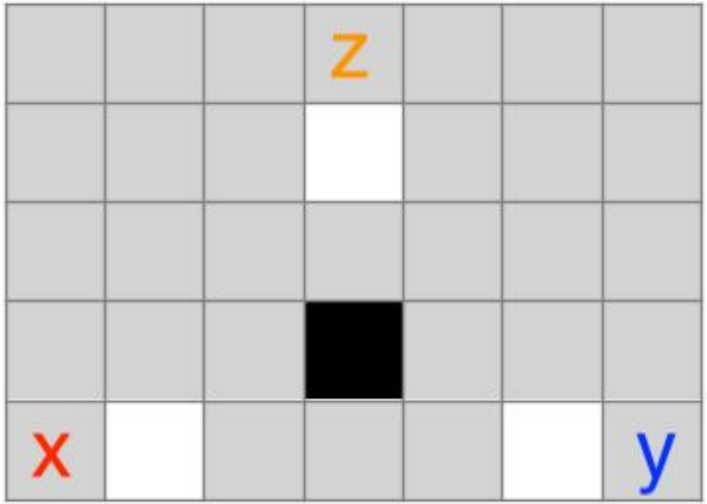
Wire



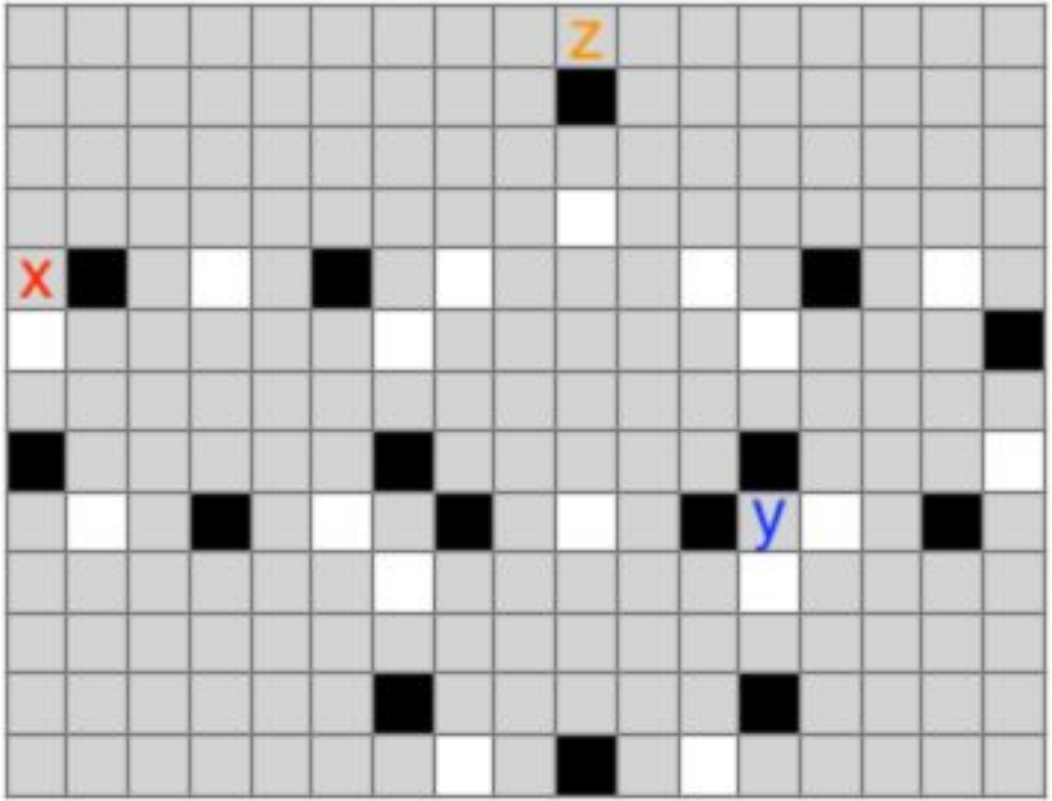
Not

Logic in Unruly

x OR y



x OR y OR z



(x OR NOT(y)) AND (NOT(x) OR y OR z)

Plan

Any NP problem $\leq_p$ SAT

$\leq_p$ 3SAT

$\leq_p$ Planar 3SAT

$\leq_p$ Unruly? ← Done!

So Unruly is NP-complete!

Questions

1. Are these tactics always enough? No!
2. If not, is there a set of tactics which would be? Equivalent to P = NP

Thanks to

- Simon Tatham
- Ciorstaidh MacGlone
- David MacIver
- Susz Fleming, Gareth Smith, Mike Prior-Jones and the rest of the Scooby Gang
- And YOU, for being a lovely audience!