TITLEPAGE

Bc., Ing., Ph.D.

October 22, 2018

Die

Die

- Hardcode all six possibilities
- Rotate
- ...
- Profit $ $ $

Horsemeat - alternative solution (matrix multiplication)

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```
    int x;
    int beg=0;
    for(int i=0;i<4;i++) {
        cin>>x;
        beg+=x;
        if(i<3)
            beg<<=8;
    }

    stavy1.insert({beg, 1.0});

    vector<double> prs(2);
    int pl=0; // 0 white, 1 black

    while(true) {
        // move
        for(auto && s: stavy1) {
            // if(s.second==0) continue; // WTF

            int stav=s.first;
            int x,y, x2, y2;

            if(pl==0) {
                x=(stav>>24)&255;
                y=(stav>>16)&255;
                x2=(stav>>8)&255;
                y2=(stav)&255;
            }else{
                x2=(stav>>24)&255;
                y2=(stav>>16)&255;
                x=(stav>>8)&255;
                y=(stav)&255;
            }

            int no_news=0;

            set<pair<int,int>> tahy = { {-2, -1},
                                        {-2, +1},
                                        {+2, -1},
                                        {+2, +1},
                                        {-1, -2},
                                        {-1, +2},
                                        {+1, -2},
                                        {+1, +2} };

            for(auto && t: tahy) {
                int nx,ny;
                nx=x+t.first;
                ny=y+t.second;
                if(nx>=1 && nx<=8 && ny>=1 && ny<=8)
                    no_news++;
            }

            for(auto && t: tahy) {
                int nx,ny;
                nx=x+t.first;
                ny=y+t.second;
                if(nx>=1 && nx<=8 && ny>=1 && ny<=8) {
                    int newState=0;
                    if(pl==0) {
                        newState+=nx<<24;
                        newState+=ny<<16;
                        newState+=x2<<8;
                        newState+=y2;
                    }else{
                        newState+=x2<<24;
                        newState+=y2<<16;
                        newState+=nx<<8;
                        newState+=ny;
                    }

                    //cout<<nx<<" "<<ny<<" "<<newState<<"AAAAA"<<endl;

                    if(nx==x2 && ny==y2) {
                    //cout<<"PLUS"<<s.second/no_news<<" "<<pl<<endl;
                        prs[pl]+=s.second/no_news;
                    }else
                    stavy2[newState]+=s.second/no_news;
                }
            }

        }

        // sun
        double sun=0.0;
        for(auto && s: stavy2) {
            sun+=s.second;
        }

        if(sun<0.000001) break;

        pl=1-pl;


        stavy1=std::move(stavy2);
        stavy2.clear();
    }

    //cout<<prs[0]<<' '<<prs[1];

    if(prs[0]<prs[1]) cout<<"black"<<endl;
    else cout<<"white"<<endl;

    return 0;
}
```

Horsemeat - alternative solution (matrix multiplication)

```
    int x;
    int beg=0;
    for(int i=0;i<4;i++) {
        cin>>x;
        beg+=x;
        if(i<3)
            beg<<=8;
    }

    stavy1.insert({beg, 1.0});

    vector<double> prs(2);
    int pl=0; // 0 white, 1 black

    while(true) {
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        for(auto && s: stavy1) {
            // if(s.second==0) continue; // WTF

            int stav=s.first;
            int x,y, x2, y2;

            if(pl==0) {
                x=(stav>>24)&255;
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                                        {+2, -1},
                                        {+2, +1},
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                                        {+1, -2},
                                        {+1, +2} };

            for(auto && t: tahy) {
                int nx,ny;
                nx=x+t.first;
                ny=y+t.second;
                if(nx>=1 && nx<=8 && ny>=1 && ny<=8)
                    no_news++;
            }

            for(auto && t: tahy) {
                int nx,ny;
                nx=x+t.first;
                ny=y+t.second;
                if(nx>=1 && nx<=8 && ny>=1 && ny<=8) {
                    int newState=0;
                    if(pl==0) {
                        newState+=nx<<24;
                        newState+=ny<<16;
                        newState+=x2<<8;
                        newState+=y2;
                    }else{
                        newState+=x2<<24;
                        newState+=y2<<16;
                        newState+=nx<<8;
                        newState+=ny;
                    }

                    //cout<<nx<<" "<<ny<<" "<<newState<<"AAAAA"<<endl;

                    if(nx==x2 && ny==y2) {
                    //cout<<"PLUS"<<s.second/no_news<<" "<<pl<<endl;
                        prs[pl]+=s.second/no_news;
                    }else
                    stavy2[newState]+=s.second/no_news;
                }
            }

        }

        // sun
        double sun=0.0;
        for(auto && s: stavy2) {
            sun+=s.second;
        }

        if(sun<0.000001) break;

        pl=1-pl;


        stavy1=std::move(stavy2);
        stavy2.clear();
    }

    //cout<<prs[0]<<' '<<prs[1];

    if(prs[0]<prs[1]) cout<<"black"<<endl;
    else cout<<"white"<<endl;

    return 0;
}
```

```
#define pb push_back
#define mp make_pair

typedef vector<int> vi;
typedef pair<int,int> pii;
typedef long long ll;
typedef long double ld;

const int maxn = 1000 + 5;

typedef array<array<ld, 8>, 8> stan;

stan pusty_stan() {
    stan s;
    rep (i, 8) rep(j, 8) s[i][j] = 0.0;
    return s;
}

bool in_range(int x) {
    return x >=0 && x < 8;
}

bool valid(int i, int j, int dx, int dy) {
    bool kon = ((abs(dx) == 2 && abs(dy) == 1) || (abs(dx) == 1 && abs(dy) == 2));
    return kon && in_range(dx + i) && in_range(dy + j);
}

stan kolejny(const stan& obecny, const stan& drugi) {
    stan res = pusty_stan();

    rep(i, 8) {
        rep(j, 8) {
            vector<pii> pos;
            for (int k = -2; k <= 2; k++) {
                for (int l = -2; l <= 2; l++) {
                    if (!valid(i, j, k, l)) continue;
                    pos.push_back({i + k, j + l});
                }
            }

            ld ile = (ld)pos.size();
            for (auto p : pos) {
                int x = p.first;
                int y = p.second;
                res[x][y] += obecny[i][j] * ((ld)1.0 - obecny[i][j] * drugi[i][j]) / ile;
            }
        }
    }

    return res;
}

pair<ld, ld> go(int iter, stan& graczA, stan& graczB, ld wynikA, ld wynikB) {
    //printf("a: %Lf, b: %Lf\n", wynikA, wynikB);
    if (iter >= 60) {
        return {wynikA, wynikB};
    }

    auto nowyA = kolejny(graczA, graczB);
    rep(i, 8) {
        rep(j, 8) {
            wynikA += nowyA[i][j] * graczB[i][j];
        }
    }

    auto nowyB = kolejny(graczB, nowyA);
    rep(i, 8) {
        rep(j, 8) {
            wynikB += nowyA[i][j] * nowyB[i][j];
        }
    }

    return go(iter + 1, nowyA, nowyB, wynikA, wynikB);
}

int main(){
    int a, b;
    int p, q;

    scanf("%d %d %d %d", &a, &b, &p, &q);
    a--;
    b--;
    p--;
    q--;

    auto graczA = pusty_stan();
    graczA[a][b] = 1.0;

    auto graczB = pusty_stan();
    graczB[p][q] = 1.0;

    auto wynik = go(0, graczA, graczB, 0.0, 0.0);

    //printf("%Lf, %Lf\n", wynik.first, wynik.second);

    if (abs(wynik.first - wynik.second) < (ld)0.000001) {
        puts("draw");
    } else if (wynik.first > wynik.second) {
        puts("white");
    } else {
        puts("black");
    }
}
```

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    int x;
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        double sun=0.0;
        for(auto && s: stavy2) {
            sun+=s.second;
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        stavy1=std::move(stavy2);
        stavy2.clear();
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    //cout<<prs[0]<<' '<<prs[1];

    if(prs[0]<prs[1]) cout<<"black"<<endl;
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    return 0;
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bool valid(int i, int j, int dx, int dy) {
    bool kon = ((abs(dx) == 2 && abs(dy) == 1) || (abs(dx) == 1 && abs(dy) == 2));
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}

stan kolejny(const stan& obecny, const stan& drugi) {
    stan res = pusty_stan();

    rep(i, 8) {
        rep(j, 8) {
            vector<pii> pos;
            for (int k = -2; k <= 2; k++) {
                for (int l = -2; l <= 2; l++) {
                    if (!valid(i, j, k, l)) continue;
                    pos.push_back({i + k, j + l});
                }
            }

            ld ile = (ld)pos.size();
            for (auto p : pos) {
                int x = p.first;
                int y = p.second;
                res[x][y] += obecny[i][j] * ((ld)1.0 - obecny[i][j] * drugi[i][j]) / ile;
            }
        }
    }

    return res;
}

pair<ld, ld> go(int iter, stan& graczA, stan& graczB, ld wynikA, ld wynikB) {
    //printf("a: %Lf, b: %Lf\n", wynikA, wynikB);
    if (iter >= 60) {
        return {wynikA, wynikB};
    }

    auto nowyA = kolejny(graczA, graczB);
    rep(i, 8) {
        rep(j, 8) {
            wynikA += nowyA[i][j] * graczB[i][j];
        }
    }

    auto nowyB = kolejny(graczB, nowyA);
    rep(i, 8) {
        rep(j, 8) {
            wynikB += nowyA[i][j] * nowyB[i][j];
        }
    }

    return go(iter + 1, nowyA, nowyB, wynikA, wynikB);
}

int main(){
    int a, b;
    int p, q;

    scanf("%d %d %d %d", &a, &b, &p, &q);
    a--;
    b--;
    p--;
    q--;

    auto graczA = pusty_stan();
    graczA[a][b] = 1.0;

    auto graczB = pusty_stan();
    graczB[p][q] = 1.0;

    auto wynik = go(0, graczA, graczB, 0.0, 0.0);

    //printf("%Lf, %Lf\n", wynik.first, wynik.second);

    if (abs(wynik.first - wynik.second) < (ld)0.000001) {
        puts("draw");
    } else if (wynik.first > wynik.second) {
        puts("white");
    } else {
        puts("black");
    }
}
```

```

#include <bits/stdc++.h>

using namespace std;

int n = 10000;

int isin(int a) {
    return a<8 && a>=0;
}

int posmoves(int x, int y) {
    int p = 0;
    if(isin(x+1) && isin(y+2)) p++;
    if(isin(x+1) && isin(y-2)) p++;
    if(isin(x+2) && isin(y+1)) p++;
    if(isin(x+2) && isin(y-1)) p++;
    if(isin(x-1) && isin(y+2)) p++;
    if(isin(x-1) && isin(y-2)) p++;
    if(isin(x-2) && isin(y+1)) p++;
    if(isin(x-2) && isin(y-1)) p++;
    return p;
}

vector<vector<vector<long double> > > b(8, vector<vector<long double>>( 8, vector<long double> (n,0)));
vector<vector<vector<long double> > > w(8, vector<vector<long double>>( 8, vector<long double> (n,0)));

int main() {
    int bx, by, wx, wy;
    cin >> bx >> by >> wx >> wy;
    bx--; by--; wx--; wy--;
    b[bx][by][0]=1;
    w[wx][wy][0]=1;
    for(int i = 1; i<n; i++) {
        for(int j = 0; j<8; j++) {
            for(int k = 0; k<8; k++) {

                if(isin(j+1) && isin(k+2)) { w[j][k][i] += w[j+1][k+2][i-1]/posmoves(j+1,k+2); }
                if(isin(j+1) && isin(k-2)) { w[j][k][i] += w[j+1][k-2][i-1]/posmoves(j+1,k-2); }
                if(isin(j+2) && isin(k+1)) { w[j][k][i] += w[j+2][k+1][i-1]/posmoves(j+2,k+1); }
                if(isin(j+2) && isin(k-1)) { w[j][k][i] += w[j+2][k-1][i-1]/posmoves(j+2,k-1); }
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                if(isin(j-2) && isin(k+1)) { w[j][k][i] += w[j-2][k+1][i-1]/posmoves(j-2,k+1); }
                if(isin(j-2) && isin(k-1)) { w[j][k][i] += w[j-2][k-1][i-1]/posmoves(j-2,k-1); }

                if(isin(j+1) && isin(k+2)) { b[j][k][i] += b[j+1][k+2][i-1]/posmoves(j+1,k+2); }
                if(isin(j+1) && isin(k-2)) { b[j][k][i] += b[j+1][k-2][i-1]/posmoves(j+1,k-2); }
                if(isin(j+2) && isin(k+1)) { b[j][k][i] += b[j+2][k+1][i-1]/posmoves(j+2,k+1); }
                if(isin(j+2) && isin(k-1)) { b[j][k][i] += b[j+2][k-1][i-1]/posmoves(j+2,k-1); }
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                if(isin(j-2) && isin(k-1)) { b[j][k][i] += b[j-2][k-1][i-1]/posmoves(j-2,k-1); }
            }
        }
    }
    long double wwin=0, bwin=0;
    for(int j = 0; j<8; j++) {
        for(int k = 0; k<8; k++) {
            for(int i = 1; i<n; i++) {
                bwin+= w[j][k][i] * b[j][k][i];
                wwin+= w[j][k][i] * b[j][k][i-1];
            }
        }
    }
    if(fabs(wwin-bwin)<0.000001) {
        cout << "draw";
    }
    else if(wwin > bwin) {
        cout << "white";
    }
    else {
        cout << "black";
    }
    cout << endl;
}
```

Horsemeat - alternative solution

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```python
l = [2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2

i1, j1 = [int(x)-1 for x in input().split()]
i2, j2 = [int(x)-1 for x in input().split()]


res = l[(i1+j1*8)*64+(i2+j2*8)]

if res == 0:
    print("draw")
elif res == 1:
    print("white")
else:
    print("black")
```

Horsemeat - alternative solution

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l = [2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2, 1, 2, 1, 2, 1, 1, 2, 1, 2, 1, 2, 1, 2

i1, j1 = [int(x)-1 for x in input().split()]
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res = l[(i1+j1*8)*64+(i2+j2*8)]

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l = [2, 1, 2, 1, 2, 1, 2, 1,
     1, 2, 1, 2, 1, 2, 1, 2,
     2, 1, 2, 1, 2, 1, 2, 1,
     1, 2, 1, 2, 1, 2, 1, 2,
     2, 1, 2, 1, 2, 1, 2, 1,
     1, 2, 1, 2, 1, 2, 1, 2,
     2, 1, 2, 1, 2, 1, 2, 1,
     1, 2, 1, 2, 1, 2, 1, 2, 1, 2, 1, 2, 1, 2, 1, 2, 2, 1, 2,

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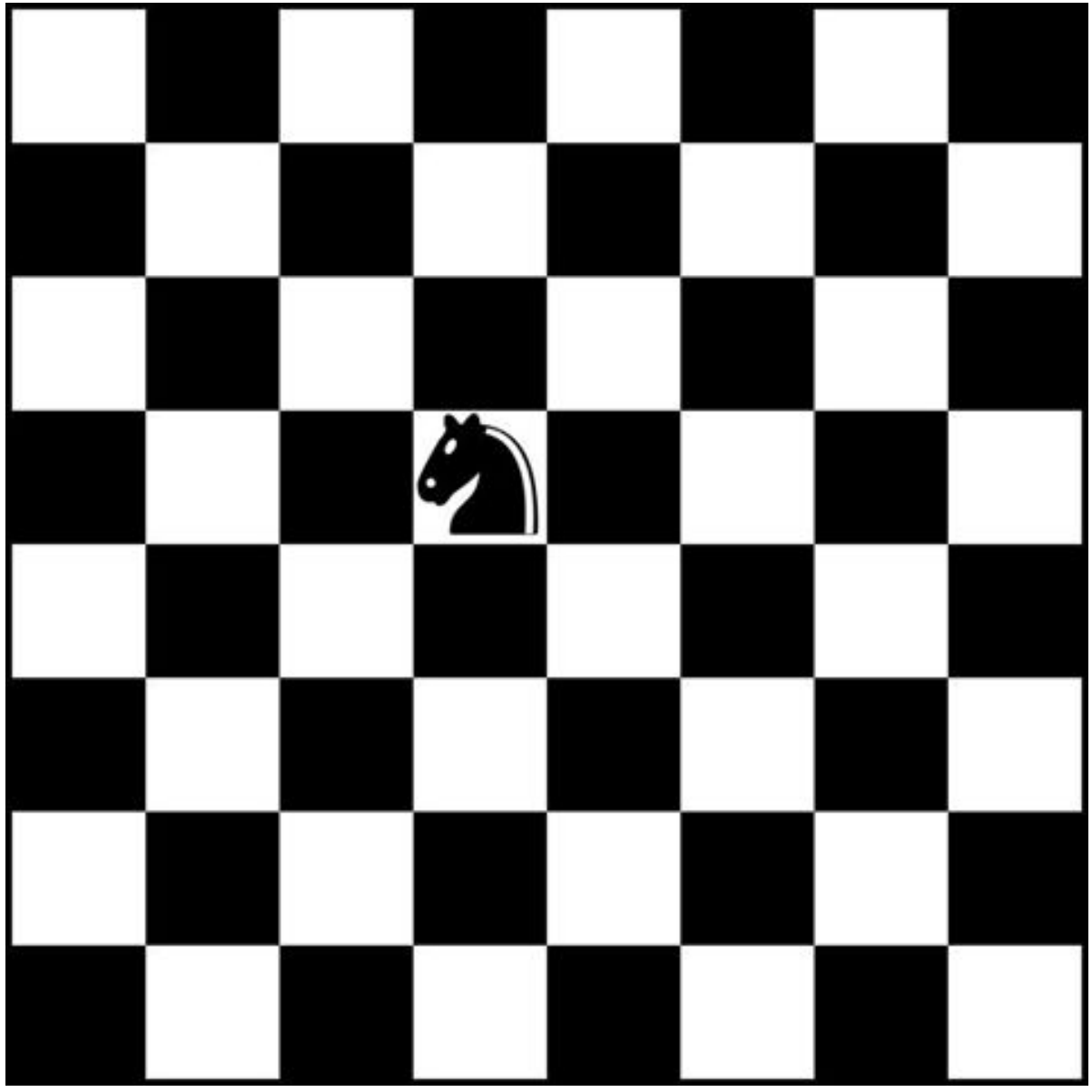
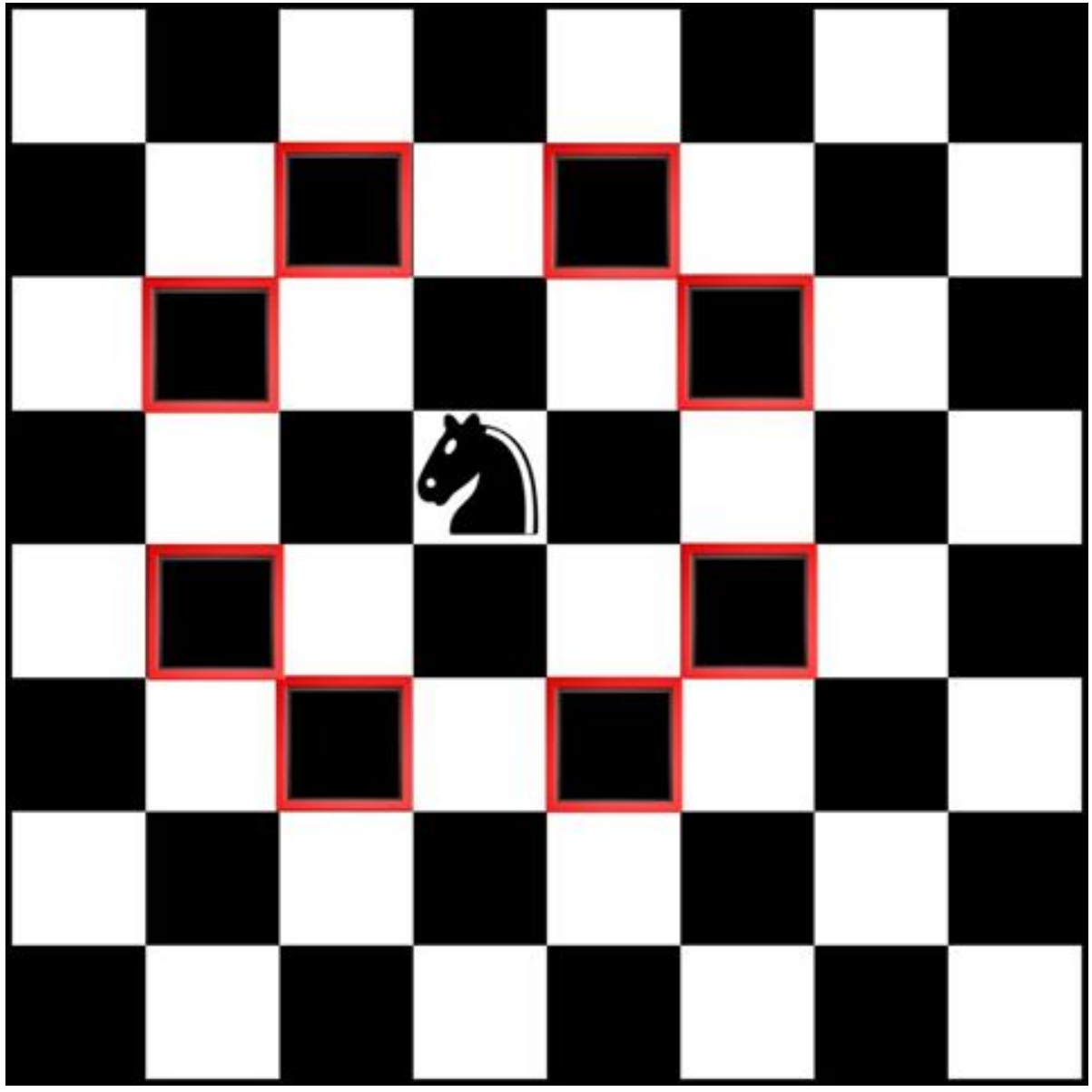
```

Observation

Horsemeat



Horsemeat



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- Fill the 5000×5000 grid with the distance to the nearest guard.
- Use BFS with multiple starts.
- Query in constant time

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Complexity $O(N^2 + Q)$

Security Guards - alternative solution

- Fill the 5000×5000 grid with 1 on guard positions and 0 otherwise.
- Create 2D prefix sum.
- For each query use binary search by answer.

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Complexity $O(N^2 + Q \log N)$

Lightning

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- Dynamic Programming
- Parameters:
  - position in bit string
  - number of ones so far
  - carry
- Expand each state by adding 1 or 0

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  - position in bit string
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Complexity $O(N\,K)$

Split Game

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- Each impartial game is equivalent to NIM.
- Sum of games has nimber equivalent to XOR of nimbers of individual games.
- Note that adding two same piles do not change the outcome.
- We precompute nimbers up to piles of size 2000 (DP).
- XOR nimbers of games on the input.
- If XOR is zero second player wins, otherwise first player wins.

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Split Game

- Each impartial game is equivalent to NIM.
- Sum of games has nimber equivalent to XOR of nimbers of individual games.
- Note that adding two same piles do not change the outcome.
- We precompute nimbers up to piles of size 2000 (DP).
- XOR nimbers of games on the input.
- If XOR is zero second player wins, otherwise first player wins.

Complexity $O(N^2 \log N)$

If you try hard, you can achieve $O(N^2)$

Rulette

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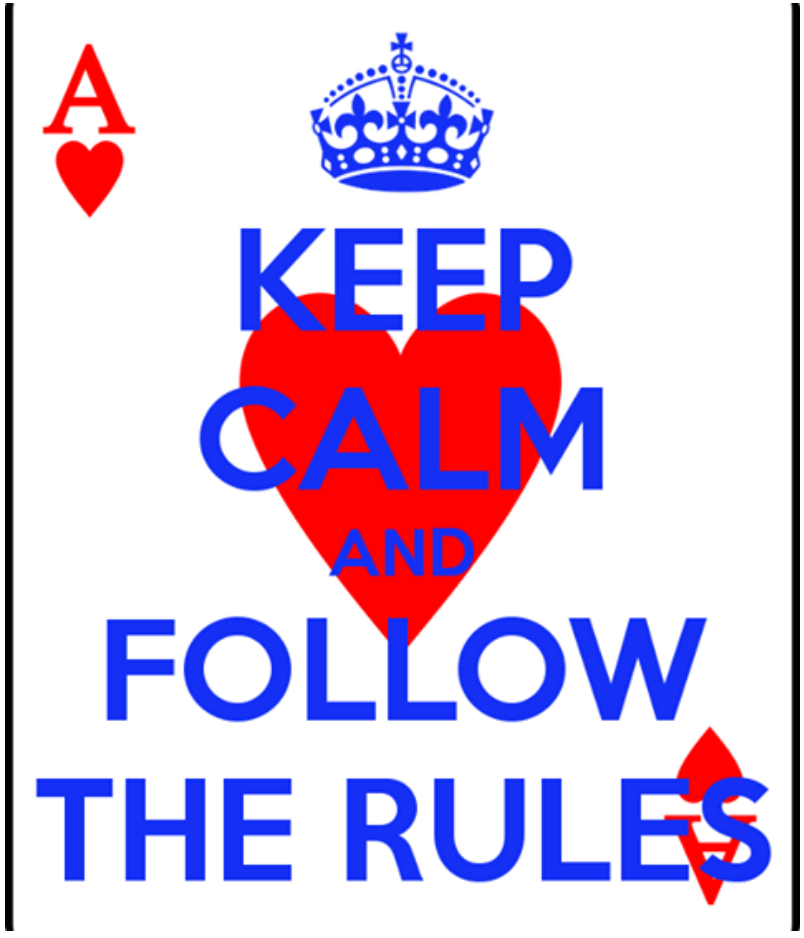

Rulette

1. If you have at least 4 cards in your hand then add 1 to the value. Also add to the value the multiple of the number of J's in your hand and the score of the first card in your hand.
2. If you have at least 2 cards of the same suit in your hand then multiply the value by 2.
3. If you have at least one card of each suit in your hand then multiply the value by 2.
4. If the count of black (Clubs and Spades) and the count of red (Hearts and Diamonds) cards in your hand differ then add the absolute difference of the counts to the value.
5. If the value is currently even then add all positive integer divisors of the value (including 1 and the value itself) to the value.
6. If there are exactly 4 cards of rank 7 in your hand then subtract 11^2 from the value.
7. If the value is currently non-negative then add the score of the lowest score card in your hand to the value.
8. If the value is currently negative then multiply the value by -1.
9. If there are at least 3 cards of Diamond suit in your hand then add 1 to the value and swap ranks of all 6's to 9's, all 9's to 6's, all 2's to 5's, and all 5's to 2's in your hand at once.
10. If there is a **straight** in your hand then add five times the number of A's in your hand to the value.
11. If the value was modified by the rules more than 8 times so far then add the number of 1's bits in the binary representation of the value to the value.
12. If there is at least one card of rank 2 in your hand then apply once again the last rule which changed the score (after that continue with rule **??**).
13. If there is at least one card of rank 2 in your hand then add the product of all distinct superfactors of the value to the value. A superfactor divides the value evenly and it is the highest power of a prime factor of the value.
14. If the value is 674 you win!

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3. If you have at least one card of each suit in your hand then multiply the value by 2.
4. Add the absolute difference between red and black suites to the value.
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3. A: If you have at least one card of each suit in your hand then multiply the value by 2.
4. Add the absolute difference between red and black suites to the value.
5. B: If there are exactly 4 cards of rank 7 in your hand then subtract 11^2 from the value.
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Simple implementation . . . with high probability of a mistake

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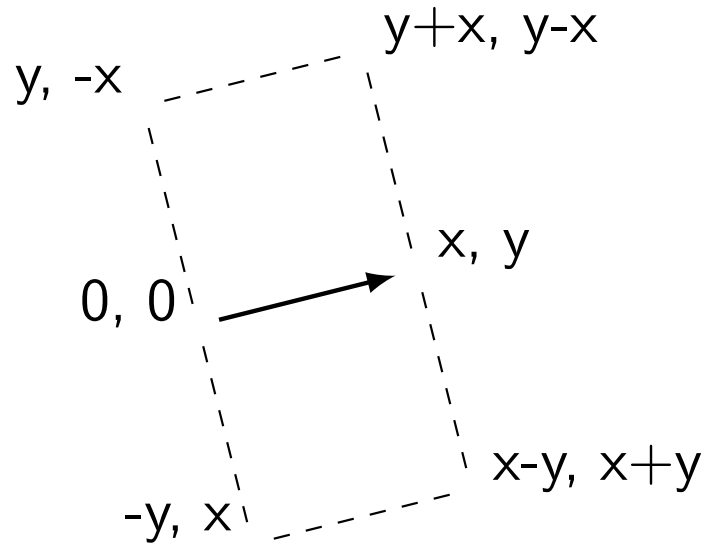

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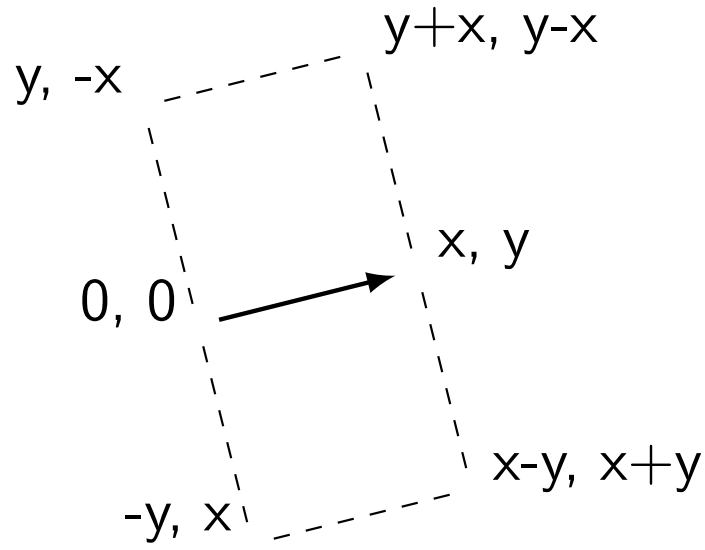

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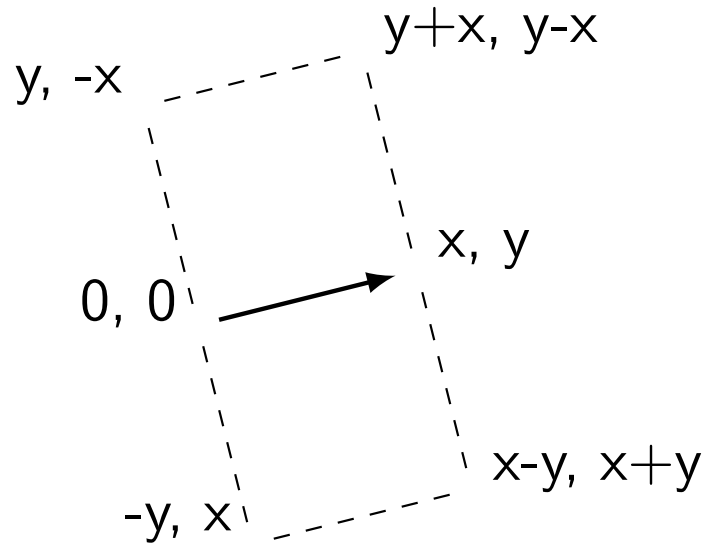

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- Note that complexity depends on SA construction. $O(N \log^2 N)$ suffices (if implemented reasonably).

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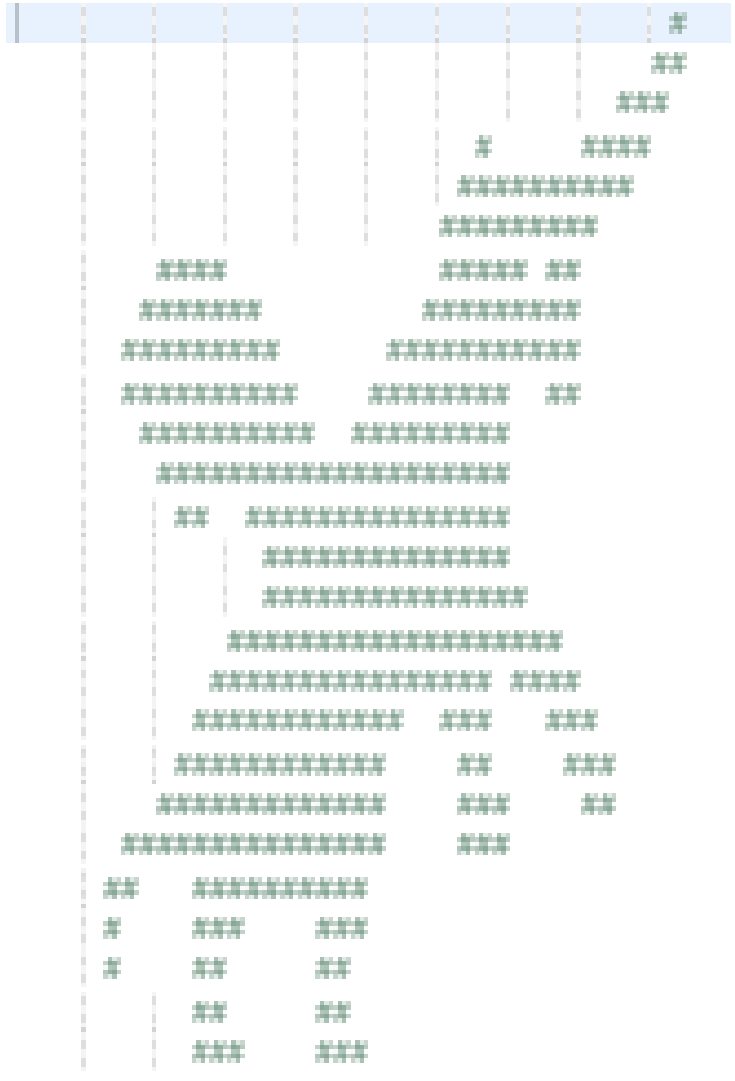
- Complexity $O((W\,B)^3)$



Thank you for your attention!