

(Downloaded from <https://cs.stanford.edu/~knuth/programs.html> and typeset on May 28, 2023)

1. Intro. Creating a graph for the distinct positions in all games of tic-tac-toe.

```
#define rank z.I      /* number of moves made */
#define link y.V      /* next vertex of same rank */
#define head x.V      /* first vertex of given rank */
#define winner w.I    /* is this a winning position? */
#define bitcode v.I    /* binary representation of this position */

#include "gb_graph.h"
#include "gb_save.h"
Vertex * pos[1 << 18];

int move[9];
int win[16] = { /* the board is now numbered 263/917/584 */
#05040, #10011, #00504, #04101, #10044, #01410, #14400, #11100};
int place[18] = {4, 4, 9, 9, 6, 6, 1, 1, 8, 8, 10, 10, 2, 2, 0, 0, 5, 5};

main()
{
    register k, l, board;
    Vertex * u, * v;
    Graph * g = gb_new_graph(5478);
    strcpy(g-util_types, "ZIIIVVZZZZZZZZ");
    strcpy(g-id, "tictactoe");
    for (k = 0; k < 8; k++) win[k + 8] = win[k] << 1;
    l = board = 0;
    pos[0] = u = v = g-vertices;
    v-rank = v-winner = v-bitcode = 0;
    v-link =  $\Lambda$ , (g-vertices + 0)-head = v;
    v-name = gb_save_string("uuu/uuu/uuu");
newlev: move[l] = 3;
tryit:
    if (¬(board & move[l])) {
        board += move[l] & (l & 1 ? #55555 : #aaaaa);
        if (pos[board]) {
            gb_new_arc(v, pos[board], 1);
            goto unmove;
        }
        pos[board] = ++u;
        u-rank = l + 1, u-winner = 0, u-bitcode = board;
        u-name = gb_save_string("uuu/uuu/uuu");
        for (k = 0; k < 18; k++)
            if (board & (1 << k)) u-name[place[k]] = ((l  $\oplus$  k) & 1 ? 'O' : 'X');
        u-link = (g-vertices + l + 1)-head, (g-vertices + l + 1)-head = u;
        gb_new_arc(v, u, 1);
        for (k = 0; k < 16; k++)
            if ((board & win[k])  $\equiv$  win[k]) {
                u-winner = 1;
                goto unmove;
            }
        }
    if (l  $\equiv$  8) goto unmove;
    l++, v = u;
    goto newlev;
unmove:
}
```

```

    }
    tryagain: move[l] <= 2;
    if (move[l] < (1 << 18)) goto tryit;
    if (l > 0) {
        l--, v = pos[board & ~move[l]];
        unmove: board &= ~move[l];
        goto tryagain;
    }
    save_graph(g, "/tmp/tictactoe.gb");
}

```

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