

CISP 430

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Assignment 3

MAZE RECURSION

Maze 1 Source code:

```
/*  
    A recursive algorithm to determine all possible paths through a maze.
```

```
    Dan Ross,  
#include <iostream>  
using namespace std;  
  
#define SIZE 10  
//#define DEBUG  
  
struct cell_type {  
    int row;  
  
    int col;  
    int dir;  
};  
typedef struct cell_type Cell;
```

```
Cell sol[SIZE * SIZE];  
  
// the maze  
int maze[SIZE][SIZE] = {  
    1,1,1,1,1,1,1,1,1,1,  
    1,0,0,0,0,0,0,0,0,1,  
    1,0,1,1,1,1,1,1,0,1,  
    1,0,1,0,0,0,0,1,0,1,  
    1,0,1,1,1,1,1,1,0,1,  
    1,0,0,0,0,0,0,0,0,1,  
    1,0,1,1,1,1,1,1,0,1,  
    1,0,0,0,0,0,0,0,0,1,  
    1,0,0,0,0,0,0,0,0,1,  
    1,1,0,1,1,1,1,1,0,1,
```

```
1,1,1,1,1,1,1,1,1,1
};
```

```
// FUNCTION PROTOTYPES
```

```
void build(int);
```

```
void printSolution(int); int is_safe(int);
```

```
int getNextCell(int);
```

```
int main(void)
```

```
{
```

```
    sol[0].row = 1;
```

```
    sol[0].col = 1;
```

```
    sol[0].dir = 0;
```

```
    clock_t start = clock();
```

```
    // start recursive solution
```

```
    build(0);
```

```
    clock_t end = clock();
```

```
    cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
```

```
endl;
```

```
}
```

```
void build(int n)
```

```
{
```

```
    while (getNextCell(n)) {
```

```
#ifdef DEBUG
```

```
    printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n,
sol[n].row, sol[n].col, sol[n + 1].row, sol[n + 1].col);
```

```
#endif
```

```
    if (is_safe(n)) {
```

```
        if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
```

```
            printSolution(n + 1);
```

```
        else
```

```
            build(n + 1);
```

```
    }
```

```
}
```

```
}
```

```
void printSolution(int n)
```

```
{
```

```
    int i;
```

```

        printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
            printf("(%d, %d) ", sol[i].row, sol[i].col); printf("\n\n");
    }

    int getNextCell(int n)
    {
        sol[n + 1].row = sol[n].row;
        sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

        switch (sol[n].dir) {
        case 0: sol[n].dir = 'e';
            sol[n + 1].col++;

        return 1; case 'e':
            sol[n].dir = 's'; sol[n + 1].row++; return 1;
        case 's':
            sol[n].dir = 'w';
            sol[n + 1].col--; return 1;
        case 'w':
            sol[n].dir = 'n';
            sol[n + 1].row--; return 1;
        case 'n':
            return 0;    // all directions have been tried
        }
        return 0;    // make compiler happy
    }

    int is_safe(int n)
    {
        int i;

        if (maze[sol[n + 1].row][sol[n + 1].col])
            return 0;

        for (i = 0; i < n; i++)

            if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

        return 1;
    }

```

Output:

Microsoft Visual Studio Debug Console

```
A solution was found at:
(1, 1) (1, 2) (1, 3) (1, 4) (1, 5) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (5, 8) (6, 8) (7, 8) (8, 8)

A solution was found at:
(1, 1) (1, 2) (1, 3) (1, 4) (1, 5) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (5, 8) (5, 7) (5, 6) (5, 5) (5, 4) (5, 3) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (7, 4) (7, 5) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (5, 1) (5, 2) (5, 3) (5, 4) (5, 5) (5, 6) (5, 7) (5, 8) (6, 8) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (7, 4) (7, 5) (7, 6) (7, 7) (7, 8) (8, 8)

Time: 0.003 seconds

c:\Users\roman\source\repos\MAZE\Debug\MAZE.exe (process 45456) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

Maze 2 Source Code:

```
/*
    A recursive algorithm to determine all possible paths through a maze.

    Dan Ross
*/
#include <iostream>
using namespace std;

#define SIZE 10
//#define DEBUG

// GLOBAL DATA

struct cell_type {
    int row;
    int col;
    int dir;
};
typedef struct cell_type Cell;

Cell sol[SIZE * SIZE];

int maze[SIZE][SIZE] = {
    1,1,1,1,1,1,1,1,1,1,
    1,0,0,0,0,0,0,0,0,1,
    1,0,1,1,1,0,1,1,0,1,
    1,0,1,0,0,0,0,1,0,1,
    1,0,1,1,1,1,1,1,0,1,
    1,0,0,0,0,0,0,0,0,1,
    1,0,1,1,1,1,1,1,0,1,
    1,0,0,0,0,0,0,0,0,1,
    1,0,1,1,1,1,1,1,0,1,
    1,0,0,0,0,0,0,0,0,1,
    1,1,0,1,1,1,1,1,0,1,
    1,1,1,1,1,1,1,1,1,1
};

// FUNCTION PROTOTYPES
void build(int);
void printSolution(int); int is_safe(int);
```

```

int getNextCell(int);

int main(void)
{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;

    clock_t start = clock();
    // start recursive solution
    build(0);
    clock_t end = clock();

    cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{
    while (getNextCell(n)) {
#ifdef DEBUG
        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif

        if (is_safe(n)) {

            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                build(n + 1);
        }
    }
}

void printSolution(int n)
{
    int i;

    printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
        printf("(%d, %d) ", sol[i].row, sol[i].col); printf("\n\n");
}

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;
}

```

```

        switch (sol[n].dir) {
case 0: sol[n].dir = 'e';
        sol[n + 1].col++; return 1;
case 'e': sol[n].dir = 's';
        sol[n + 1].row++; return 1;
case 's': sol[n].dir = 'w';
        sol[n + 1].col--;

return 1; case 'w':
        sol[n].dir = 'n';
        sol[n + 1].row--; return 1;
case 'n':
        return 0;    // all directions have been tried
}
return 0;    // make compiler happy
}

int is_safe(int n)
{
    int i;

    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    for (i = 0; i < n; i++)
        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}

```

Output:

Microsoft Visual Studio Debug Console

```
A solution was found at:
(1, 1) (1, 2) (1, 3) (1, 4) (1, 5) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (5, 8) (6, 8) (7, 8) (8, 8)

A solution was found at:
(1, 1) (1, 2) (1, 3) (1, 4) (1, 5) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (5, 8) (5, 7) (5, 6) (5, 5) (5, 4) (5, 3) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (7, 4) (7, 5) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (5, 1) (5, 2) (5, 3) (5, 4) (5, 5) (5, 6) (5, 7) (5, 8) (6, 8) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (7, 4) (7, 5) (7, 6) (7, 7) (7, 8) (8, 8)

Time: 0.005 seconds

C:\Users\roman\source\repos\MAZE\src\Debug\MAZE.exe (process 33216) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

Maze 3 Source Code:

```
/*
```

A recursive algorithm to determine all possible paths through a maze.

Dan Ross,

```
*/
```

```
#include <iostream>
using namespace std;
```

```
#define SIZE 10
//#define DEBUG
```

```
// GLOBAL DATA
```

```
struct cell_type {
int row;
int col;
int dir; //
};
typedef struct cell_type Cell;
```

```
Cell sol[SIZE * SIZE];
```

```
// the maze
int maze[SIZE][SIZE] = {
1,1,1,1,1,1,1,1,1,1,
1,0,0,0,0,1,1,0,0,1,
1,0,1,1,0,0,1,1,1,1,
1,0,0,0,0,1,0,0,0,1,
1,1,0,1,1,0,0,1,1,1,
1,1,0,1,1,0,0,1,1,1,
```

```

1,0,0,1,0,0,1,1,1,1,
1,0,1,0,0,1,0,1,0,1,
1,0,1,0,0,1,0,0,0,1,
1,0,0,0,0,0,0,0,0,1,
1,1,1,1,1,1,1,1,1,1
};

// FUNCTION PROTOTYPES
void build(int);
void printSolution(int); int is_safe(int);
int getNextCell(int);

int main(void)
{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;

    clock_t start = clock();

    build(0);
    clock_t end = clock();

    cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{
    while (getNextCell(n)) {

#ifdef DEBUG
        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif

        if (is_safe(n)) {

            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                build(n + 1);
        }
    }
}

/*
Outputs the current solution array.
*/
void printSolution(int n)
{
    int i;

```

```

        printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
            printf("(%d, %d) ", sol[i].row, sol[i].col); printf("\n\n");
    }

```

```

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

    switch (sol[n].dir) {
case 0: sol[n].dir = 'e';
        sol[n + 1].col++;

return 1; case 'e':
        sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':
        sol[n].dir = 'w';
        sol[n + 1].col--; return 1;
case 'w':
        sol[n].dir = 'n';
        sol[n + 1].row--; return 1;
case 'n':
        return 0;
    }
return 0;
}

```

```

int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    for (i = 0; i < n; i++)

        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col)

            return 0;

    return 1;
}

```

Output:

[illegible]

```
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 6) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 6) (8, 7) (8, 8)

Time: 0.177 seconds

C:\Users\roman\source\repos\WAZE\WAZE\Debug\WAZE.exe (process 12848) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

```
A solution was found at:
(1, 1) (1, 2) (1, 3) (1, 4) (2, 4) (3, 4) (3, 3) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (1, 2) (1, 3) (1, 4) (2, 4) (3, 4) (3, 3) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (8, 4) (8, 5) (8, 6) (8, 7) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (8, 7) (8, 8)

Time: 0.037 seconds
```

Maze 4 Source Code:

```
/*  
  
    A recursive algorithm to determine all possible paths through a maze.  
  
    Dan Ross  
#include <iostream>  
using namespace std;  
  
#define SIZE 10  
//#define DEBUG  
  
// GLOBAL DATA  
  
// a cell type containing a row and column position  
// and the compass direction most recently moved  
struct cell_type {  
    int row;  
  
    int col;  
    int dir;  
};  
typedef struct cell_type Cell;  
  
// the solution represented as an array of Cells  
Cell sol[SIZE * SIZE];  
  
int maze[SIZE][SIZE] = { 1,1,1,1,1,1,1,1,1,1,  
    1,0,0,0,0,1,1,0,0,1,  
    1,0,1,1,0,0,1,0,1,1,  
    1,0,0,0,0,1,0,0,0,1,  
    1,1,0,1,1,0,0,0,1,1,  
    1,0,0,1,0,0,1,0,0,1,  
    1,0,1,0,0,1,0,1,0,1,  
    1,0,1,0,0,1,0,0,0,1,  
    1,0,0,0,0,0,0,0,0,1,  
    1,1,1,1,1,1,1,1,1,1  
};  
  
// FUNCTION PROTOTYPES  
void build(int);  
void printSolution(int); int is_safe(int);  
int getNextCell(int);  
  
int main(void)  
{
```

```

        // set starting position and direction
        sol[0].row = 1;
        sol[0].col = 1;
        sol[0].dir = 0;

        clock_t start = clock();
        // start recursive solution
        build(0);
        clock_t end = clock();

        cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{
    // loop while there are more possible moves
    while (getNextCell(n)) {

#ifdef DEBUG
        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif
        // check if this possibility is a valid move
        if (is_safe(n)) {

            // is the next possibility the end of the maze?
            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                // get the next move
                build(n + 1);
        }
    }
}

/*
Outputs the current solution array.
*/
void printSolution(int n)
{
    int i;

    printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
        printf("(%d, %d) ", sol[i].row, sol[i].col); printf("\n\n");
}

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col;
    sol[n + 1].dir = 0;
}

```



```
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (7, 6) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (7, 6) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (8, 7) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (7, 7) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (8, 7) (8, 8)

A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (7, 6) (8, 6) (8, 7) (8, 8)

Time: 0.177 seconds

C:\Users\roman\source\repos\MAZE\Debug\MAZE.exe (process 12848) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```


Maze 5 Source Code:

```
/*  
  
    A recursive algorithm to determine all possible paths through a maze.  
  
    Dan Ross  
#include <iostream>  
using namespace std;  
  
#define SIZE 10  
//#define DEBUG  
  
// GLOBAL DATA  
  
struct cell_type {  
    int row; int col;  
    int dir;  
};  
typedef struct cell_type Cell;  
  
// the solution represented as an array of Cells  
Cell sol[SIZE * SIZE];  
  
// the maze  
int maze[SIZE][SIZE] = { 1,1,1,1,1,1,1,1,1,1,  
    1,0,0,0,0,1,1,0,0,1,  
    1,0,1,1,0,0,1,0,1,1,  
    1,0,0,0,0,1,0,0,0,1,  
    1,1,0,1,1,0,0,0,1,1,  
    1,0,0,1,0,0,1,0,0,1,  
  
    1,0,1,0,0,0,0,1,0,1,  
    1,0,1,0,0,1,0,0,0,1,  
    1,0,0,0,0,0,0,0,0,1,  
    1,1,1,1,1,1,1,1,1,1  
};  
  
// FUNCTION PROTOTYPES  
void build(int);  
void printSolution(int); int is_safe(int);  
int getNextCell(int);  
  
int main(void)  
{  
    // set starting position and direction  
    sol[0].row = 1;  
    sol[0].col = 1;  
    sol[0].dir = 0;  
  
    clock_t start = clock();  
    // start recursive solution  
    build(0);  
    clock_t end = clock();
```

```

        cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{
    // loop while there are more possible moves
    while (getNextCell(n)) {

#ifdef DEBUG
        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif
        // check if this possibility is a valid move
        if (is_safe(n)) {

            // is the next possibility the end of the maze?
            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                // get the next move
                build(n + 1);
        }
    }
}

/*
Outputs the current solution array.
*/
void printSolution(int n)
{
    int i;

    printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
        printf("(%d, %d) ", sol[i].row, sol[i].col); printf("");
}

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

    switch (sol[n].dir) {
case 0:
    sol[n].dir = 'e'; sol[n + 1].col++; return 1;
case 'e':
    sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':
    sol[n].dir = 'w';
    sol[n + 1].col--; return 1;
case 'w':
    sol[n].dir = 'n';
    sol[n + 1].row--; return 1;

```

```

case 'n':
    return 0;    // all directions have been tried
}

return 0;    // make compiler happy
}

int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    // check if we are attempting to cross our own path
    for (i = 0; i < n; i++)

        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}

```

Microsoft Visual Studio Debug Console

Microsoft Visual Studio Debug Console

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Maze 6 Source Code:

d/*

A recursive algorithm to determine all possible paths through a maze.

Dan Ross, circa 2000-2020

*/

```
#include <iostream>
using namespace std;
```

```
#define SIZE 10
//#define DEBUG
```

```
// GLOBAL DATA
```

```
struct cell_type {
int row; int col;
int dir;
};
typedef struct cell_type Cell;
```

```
// the solution represented as an array of Cells
Cell sol[SIZE * SIZE];
```

```
// the maze
int maze[SIZE][SIZE] = { 1,1,1,1,1,1,1,1,1,1,
1,0,1,0,0,0,1,0,0,1,
1,0,0,0,1,1,1,1,0,1,
1,0,1,1,1,0,0,1,0,1,
1,0,0,0,0,0,0,1,0,1,

1,1,1,1,0,1,0,1,0,1,
1,0,0,1,1,1,0,1,0,1,
1,0,1,0,0,0,0,1,0,1,
1,0,1,0,1,1,0,0,0,1,
1,1,1,1,1,1,1,1,1,1
};
```

```
// FUNCTION PROTOTYPES
```

```
void build(int);
void printSolution(int); int is_safe(int);
int getNextCell(int);
```

```
int main(void)
{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;
```

```
    clock_t start = clock();
    // start recursive solution
```

```

        build(0);
        clock_t end = clock();

        cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{
    // loop while there are more possible moves
    while (getNextCell(n)) {

#ifdef DEBUG
        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif
        // check if this possibility is a valid move
        if (is_safe(n)) {

            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                // get the next move
                build(n + 1);
        }
    }
}

/*
Outputs the current solution array.
*/
void printSolution(int n)
{
    int i;

    printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
        printf("(%d, %d) ", sol[i].row, sol[i].col); printf("");
}

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

    switch (sol[n].dir) {
case 0:
    sol[n].dir = 'e'; sol[n + 1].col++; return 1;
case 'e':
    sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':
    sol[n].dir = 'w';
    sol[n + 1].col--; return 1;
case 'w':

```

```

        sol[n].dir = 'n';
        sol[n + 1].row--; return 1;
case 'n':
    return 0;    // all directions have been tried
}
return 0;    // make compiler happy
}

int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    // check if we are attempting to cross our own path
    for (i = 0; i < n; i++)

        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}

```

}Output:

Microsoft Visual Studio Debug Console

```

A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (4, 3) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (4, 3) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8) Time: 0.002 seconds
C:\Users\roman\source\repos\MAZE\x64\Debug\MAZE.exe (process 26524) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .

```

Make 7 Source Code:

```
/*
```


A recursive algorithm to determine all possible paths through a maze.

Dan Ross

```
*/
#include <iostream>
using namespace std;

#define SIZE 10
// #define DEBUG

// GLOBAL DATA

// a cell type containing a row and column position
// and the compass direction most recently moved
struct cell_type {
    int row; int col;
    int dir;
};
typedef struct cell_type Cell;

// the solution represented as an array of Cells
Cell sol[SIZE * SIZE];

// the maze
int maze[SIZE][SIZE] = { 1,1,1,1,1,1,1,1,1,1,
    1,0,0,0,1,1,0,0,0,1,
    1,0,1,0,0,1,0,1,0,1,
    1,0,1,1,0,0,0,1,0,1,
    1,0,0,1,1,1,1,0,0,1,
    1,1,0,0,0,0,1,0,1,1,
    1,0,0,1,1,0,0,0,0,1,
    1,0,1,0,0,0,0,1,1,1,
    1,0,0,0,1,0,0,0,0,1,
    1,1,1,1,1,1,1,1,1,1
};

// FUNCTION PROTOTYPES
void build(int);
void printSolution(int); int is_safe(int);
int getNextCell(int);

int main(void)
{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;

    clock_t start = clock();
    // start recursive solution
    build(0);
```

```

        clock_t end = clock();

        cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{
    // loop while there are more possible moves

    while (getNextCell(n)) {

#ifdef DEBUG
        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n,
sol[n].row, sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif

        // check if this possibility is a valid move
        if (is_safe(n)) {

            // is the next possibility the end of the maze?
            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                // get the next move
                build(n + 1);
        }
    }
}

/*
Outputs the current solution array.
*/
void printSolution(int n)
{
    int i;

    printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
        printf("(%d, %d) ", sol[i].row, sol[i].col); printf("");
}

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

    switch (sol[n].dir) {
case 0:
    sol[n].dir = 'e'; sol[n + 1].col++; return 1;
case 'e':
    sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':

```

```

        sol[n].dir = 'w';
        sol[n + 1].col--; return 1;
case 'w':
    sol[n].dir = 'n';
    sol[n + 1].row--; return 1;
case 'n':
    return 0;    // all directions have been tried
}
return 0;    // make compiler happy
}

int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    // check if we are attempting to cross our own path
    for (i = 0; i < n; i++)
        // if where we want to go is somewhere we've been...
        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}

```

Output:

```
A solution was found at:
(1, 1) (1, 2) (1, 3) (2, 3) (2, 4) (3, 4) (3, 5) (3, 6) (2, 6) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (4, 7) (5, 7) (6, 7) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (1, 2) (1, 3) (2, 3) (2, 4) (3, 4) (3, 5) (3, 6) (2, 6) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (4, 7) (5, 7) (6, 7) (6, 6) (7, 6) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (1, 2) (1, 3) (2, 3) (2, 4) (3, 4) (3, 5) (3, 6) (2, 6) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (4, 7) (5, 7) (6, 7) (6, 6) (6, 5) (7, 5) (7, 6) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (1, 2) (1, 3) (2, 3) (2, 4) (3, 4) (3, 5) (3, 6) (2, 6) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (4, 7) (5, 7) (6, 7) (6, 6) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (1, 2) (1, 3) (2, 3) (2, 4) (3, 4) (3, 5) (3, 6) (2, 6) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (4, 7) (5, 7) (6, 7) (6, 6) (6, 5) (5, 5) (5, 4) (5, 3) (5, 2) (6, 2) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (7, 5) (7, 6)
(8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (1, 2) (1, 3) (2, 3) (2, 4) (3, 4) (3, 5) (3, 6) (2, 6) (1, 6) (1, 7) (1, 8) (2, 8) (3, 8) (4, 8) (4, 7) (5, 7) (6, 7) (6, 6) (6, 5) (5, 5) (5, 4) (5, 3) (5, 2) (6, 2) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (7, 5) (8, 5)
(8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (5, 3) (5, 4) (5, 5) (6, 5) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (5, 3) (5, 4) (5, 5) (6, 5) (6, 6) (7, 6) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (5, 3) (5, 4) (5, 5) (6, 5) (7, 5) (7, 6) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (5, 3) (5, 4) (5, 5) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (6, 2) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (7, 5) (7, 6) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (6, 2) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (6, 2) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (7, 5) (6, 5) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8) Time: 0.012 seconds

C:\Users\rman\source\repos\MAZE\x64\Debug\MAZE.exe (process 22248) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

Maze 8 Source Code:

/*

A recursive algorithm to determine all possible paths through a maze.

Dan Ross

```

#include <iostream>
using namespace std;

#define SIZE 10
//#define DEBUG

// GLOBAL DATA

struct cell_type {
int row; int col;
int dir;
};
typedef struct cell_type Cell;

// the solution represented as an array of Cells
Cell sol[SIZE * SIZE];

int maze[SIZE][SIZE] = { 1,1,1,1,1,1,1,1,1,1,
1,0,1,0,1,0,1,0,1,1,
1,0,0,0,0,0,0,1,0,1,
1,0,1,0,1,1,1,0,1,1,
1,0,1,0,0,0,0,1,0,1,
1,1,0,1,1,1,0,0,1,1,
1,0,0,0,0,1,0,1,0,1,
1,0,1,0,1,0,0,0,1,1,
1,0,1,1,0,0,1,0,0,1,
1,1,1,1,1,1,1,1,1,1
};

// FUNCTION PROTOTYPES
void build(int);
void printSolution(int); int is_safe(int);
int getNextCell(int);

int main(void)
{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;

    clock_t start = clock();
    // start recursive solution
    build(0);
    clock_t end = clock();

    cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)
{

```

```

        // loop while there are more possible moves
        while (getNextCell(n)) {

#ifdef DEBUG

            printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
                sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif

            // check if this possibility is a valid move
            if (is_safe(n)) {

                // is the next possibility the end of the maze?
                if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                    // print the solution so far
                    printSolution(n + 1);
                else
                    // get the next move
                    build(n + 1);
            }
        }
    }

    /*
    Outputs the current solution array.
    */
    void printSolution(int n)
    {
        int i;

        printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
            printf("(%d, %d) ", sol[i].row, sol[i].col); printf("\n");
    }

    int getNextCell(int n)
    {
        // set initial position and direction for the next cell
        sol[n + 1].row = sol[n].row;
        sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

        switch (sol[n].dir) {
case 0:
            sol[n].dir = 'e'; sol[n + 1].col++; return 1;
case 'e':
            sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':
            sol[n].dir = 'w';
            sol[n + 1].col--; return 1;
case 'w':
            sol[n].dir = 'n';
            sol[n + 1].row--; return 1;
case 'n':
            return 0;    // all directions have been tried
        }
        return 0;    // make compiler happy
    }

```

```

int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    // check if we are attempting to cross our own path
    for (i = 0; i < n; i++)

        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}

```

Output:

Microsoft Visual Studio Debug Console

```

A solution was found at:
(1, 1) (2, 1) (2, 2) (2, 3) (3, 3) (4, 3) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (7, 6) (7, 7) (8, 7) (8, 8) Time: 0.001 seconds
C:\Users\roman\source\repos\MAZE\x64\Debug\MAZE.exe (process 49356) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .

```

Maze 9 Source Code:

/*

A recursive algorithm to determine all possible paths through a maze.

Dan Ross

```

*/
#include <iostream>
using namespace std;

#define SIZE 10
//#define DEBUG

// GLOBAL DATA

struct cell_type {
int row; int col;
int dir;
};
typedef struct cell_type Cell;

// the solution represented as an array of Cells
Cell sol[SIZE * SIZE];

int maze[SIZE][SIZE] = { 1,1,1,1,1,1,1,1,1,1,
1,0,0,1,1,0,0,0,0,1,
1,0,1,1,0,0,1,1,0,1,
1,0,0,0,0,1,0,0,0,1,
1,0,0,1,0,0,1,1,0,1,
1,0,1,1,0,1,0,1,0,1,
1,0,0,0,0,1,0,0,0,1,
1,0,1,0,0,1,1,1,0,1,
1,0,0,0,0,0,0,1,0,1,
1,1,1,1,1,1,1,1,1,1
};

// FUNCTION PROTOTYPES
void build(int);
void printSolution(int); int is_safe(int);
int getNextCell(int);

int main(void)
{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;

    clock_t start = clock();
    // start recursive solution
    build(0);
    clock_t end = clock();

    cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

void build(int n)

```



```

{
    // loop while there are more possible moves
    while (getNextCell(n)) {

#ifdef DEBUG

        printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);
#endif

        // check if this possibility is a valid move
        if (is_safe(n)) {

            // is the next possibility the end of the maze?
            if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
                // print the solution so far
                printSolution(n + 1);
            else
                // get the next move
                build(n + 1);
        }
    }
}

/*
Outputs the current solution array.
*/
void printSolution(int n)
{
    int i;

    printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
        printf("(%d, %d) ", sol[i].row, sol[i].col); printf("");
}

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col; sol[n + 1].dir = 0;

    switch (sol[n].dir) {
case 0:
    sol[n].dir = 'e'; sol[n + 1].col++; return 1;
case 'e':
    sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':
    sol[n].dir = 'w';
    sol[n + 1].col--; return 1;
case 'w':
    sol[n].dir = 'n';
    sol[n + 1].row--; return 1;
case 'n':
    return 0;    // all directions have been tried
    }
return 0;    // make compiler happy
}

```

```
int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    // check if we are attempting to cross our own path
    for (i = 0; i < n; i++)
        // if where we want to go is somewhere we've been...
        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}
```

Output:


```

1, 0, 1, 0, 0, 0, 0, 0, 0, 1,
1, 1, 1, 1, 1, 1, 1, 1, 1, 1
};

```

```

// FUNCTION PROTOTYPES

```

```

void build(int);

```

```

void printSolution(int); int is_safe(int);

```

```

int getNextCell(int);

```

```

int main(void)

```

```

{
    // set starting position and direction
    sol[0].row = 1;
    sol[0].col = 1;
    sol[0].dir = 0;

```

```

    clock_t start = clock();
    // start recursive solution
    build(0);
    clock_t end = clock();

```

```

    cout << "Time: " << (end - start) / (double)CLOCKS_PER_SEC << " seconds" <<
endl;
}

```

```

void build(int n)

```

```

{
    // loop while there are more possible moves
    while (getNextCell(n)) {

```

```

#ifdef DEBUG

```

```

    printf("Iteration: %d\tAt: (%d, %d)\t Trying: (%d, %d)\n", n, sol[n].row,
sol[n].col, sol[n + 1].row, sol[n + 1].col);

```

```

#endif

```

```

    // check if this possibility is a valid move
    if (is_safe(n)) {

```

```

        // is the next possibility the end of the maze?
        if (sol[n + 1].row == SIZE - 2 && sol[n + 1].col == SIZE - 2)
            // print the solution so far
            printSolution(n + 1);

```

```

        else
            // get the next move
            build(n + 1);

```

```

    }
}

```

```

/*
Outputs the current solution array.
*/

```

```

void printSolution(int n)

```

```

{
    int i;

```

```

        printf("\nA solution was found at:\n"); for (i = 0; i <= n; i++)
            printf("(%d, %d) ", sol[i].row, sol[i].col); printf("");
    }

int getNextCell(int n)
{
    // set initial position and direction for the next cell
    sol[n + 1].row = sol[n].row;
    sol[n + 1].col = sol[n].col;

    sol[n + 1].dir = 0;

    switch (sol[n].dir) {
case 0:
    sol[n].dir = 'e'; sol[n + 1].col++; return 1;
case 'e':
    sol[n].dir = 's'; sol[n + 1].row++; return 1;
case 's':
    sol[n].dir = 'w';
    sol[n + 1].col--; return 1;
case 'w':
    sol[n].dir = 'n';
    sol[n + 1].row--; return 1;
case 'n':
    return 0; // all directions have been tried
    }
return 0; // make compiler happy
}

int is_safe(int n)
{
    int i;

    // check if cell is a border cell
    if (maze[sol[n + 1].row][sol[n + 1].col]) return 0;

    // check if we are attempting to cross our own path
    for (i = 0; i < n; i++)

        if (sol[n + 1].row == sol[i].row && sol[n + 1].col == sol[i].col) return 0;

    return 1;
}

```

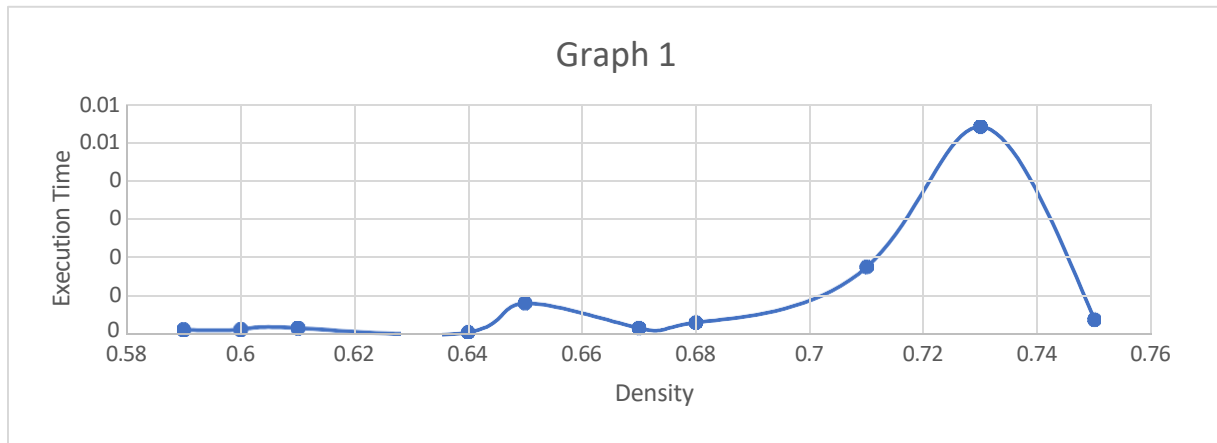
Output:

```

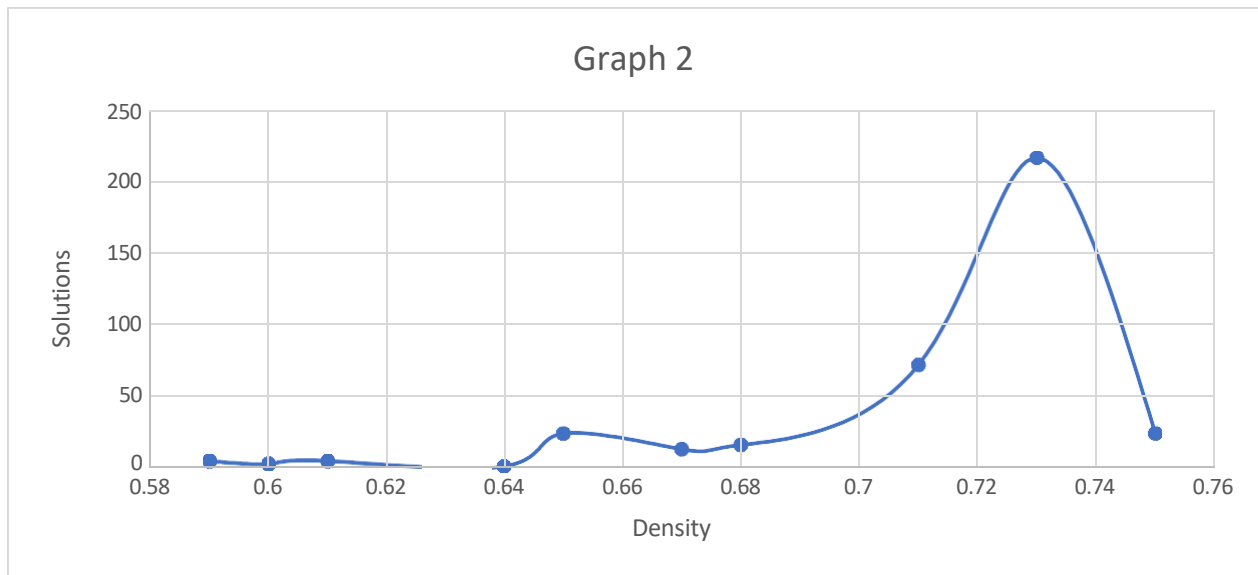
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 5) (6, 4) (6, 3) (7, 3) (8, 3) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (4, 5) (4, 4) (5, 4) (6, 4) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (4, 5) (4, 4) (5, 4) (6, 4) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (4, 5) (4, 4) (5, 4) (6, 4) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (4, 5) (4, 4) (5, 4) (6, 4) (6, 3) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (4, 5) (4, 6) (5, 6) (6, 6) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (4, 5) (4, 6) (5, 6) (6, 6) (6, 5) (6, 4) (6, 3) (7, 3) (8, 3) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (4, 5) (4, 4) (5, 4) (6, 4) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (4, 5) (4, 4) (5, 4) (6, 4) (6, 3) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 4) (5, 4) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)
A solution was found at:
(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8) (8, 8)
Time: 0.028 seconds
C:\Users\roman\source\repos\WAZE\WAZEDebug\WAZE.exe (process 12492) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .

```

Graph 1:



Graph 2:



Big Oh Analysis:

The time complexity of this maze generally increases as the openness level decreases which is because a maze with a higher openness level is more likely to have fewer dead-ends and more loops which also means that there are more possible paths to explore which would make the solution longer to find. A maze with lower openness would be more likely to have more dead-ends which would lead to less paths to explore meaning there would be less solutions, causing the time complexity to be very low.

[illegible]

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (7, 4) (8, 4) (8, 5) (8, 6) (7, 6) (6, 6) (6, 5) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (8, 7) (8, 8)

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (8, 7) (8, 8)

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (6, 3) (6, 4) (5, 4) (5, 5) (4, 5) (4, 6) (3, 6) (3, 7) (4, 7) (5, 7) (5, 8) (6, 8) (7, 8) (7, 7) (7, 6) (8, 6) (8, 7) (8, 8)

(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (4, 3) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8)

(1, 1) (2, 1) (3, 1) (4, 1) (4, 2) (5, 2) (6, 2) (6, 1) (7, 1) (8, 1) (8, 2) (8, 3) (7, 3) (7, 4) (7, 5) (6, 5) (6, 6) (7, 6) (8, 6) (8, 7) (8, 8)

A solution was found at:

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (3, 3) (2, 3) (2, 4) (2, 5) (3, 5) (4, 5) (4, 4) (5, 4) (6, 4) (6, 3) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 4) (5, 4) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (8, 3) (8, 4) (8, 5) (7, 5) (6, 5) (6, 4) (5, 4) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (6, 5) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (4, 6) (5, 6) (6, 6) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 7) (6, 8) (7, 8) (8, 8)

A solution was found at:

(1, 1) (2, 1) (3, 1) (3, 2) (4, 2) (5, 2) (5, 1) (6, 1) (7, 1) (7, 2) (7, 3) (6, 3) (6, 4) (5, 4) (4, 4) (4, 5) (3, 5) (3, 6) (4, 6) (5, 6) (6, 6) (6, 5) (7, 5) (8, 5) (8, 6) (8, 7) (8, 8)

