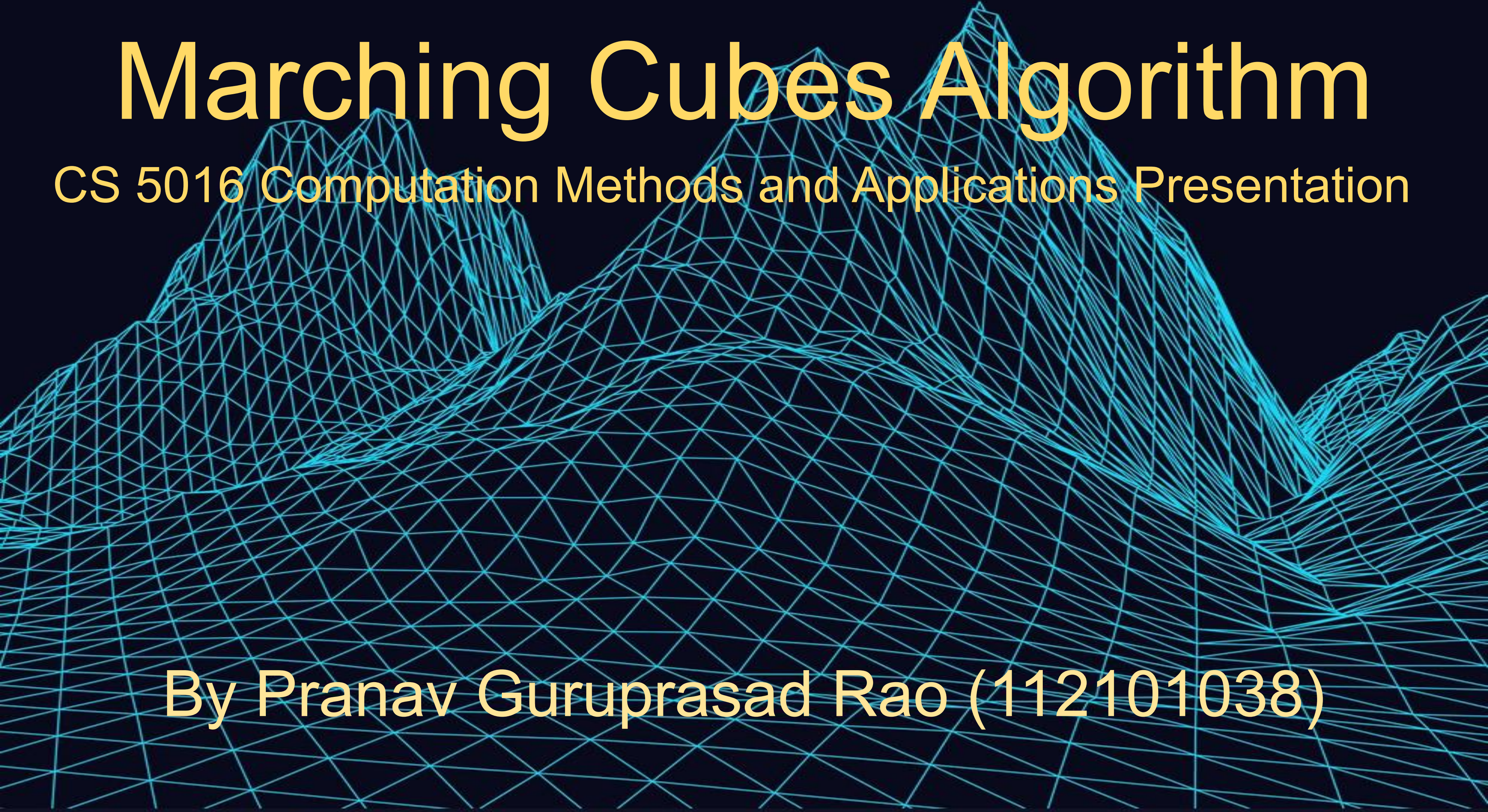

Marching Cubes Algorithm

CS 5016 Computation Methods and Applications Presentation

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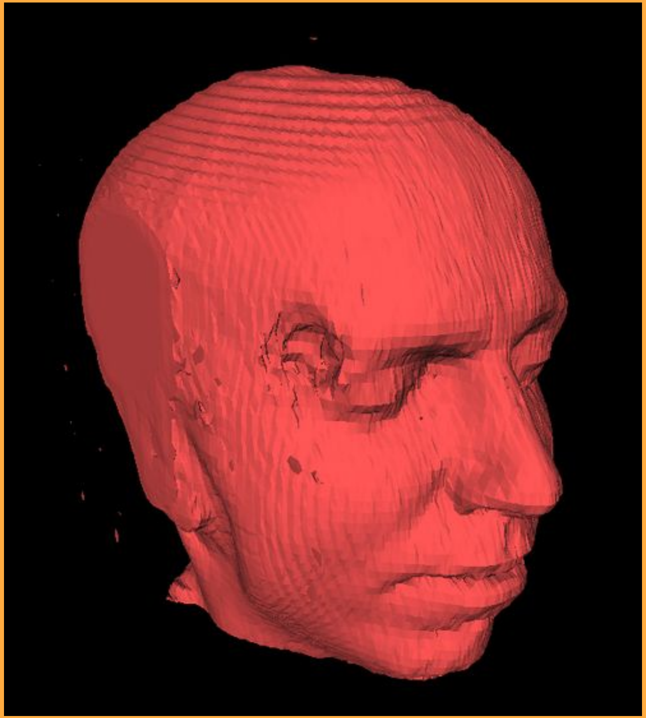
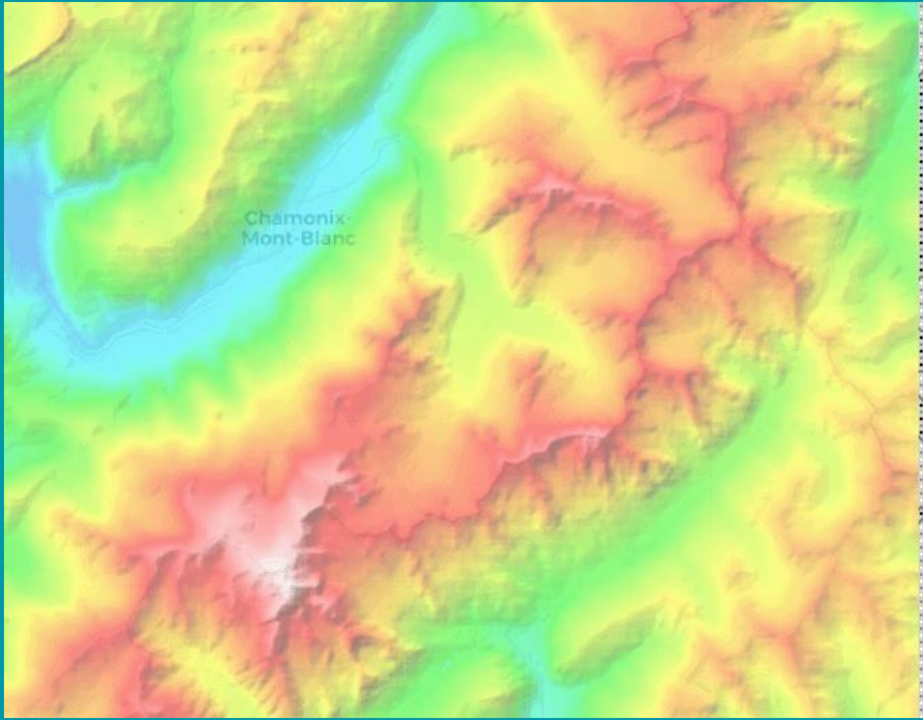
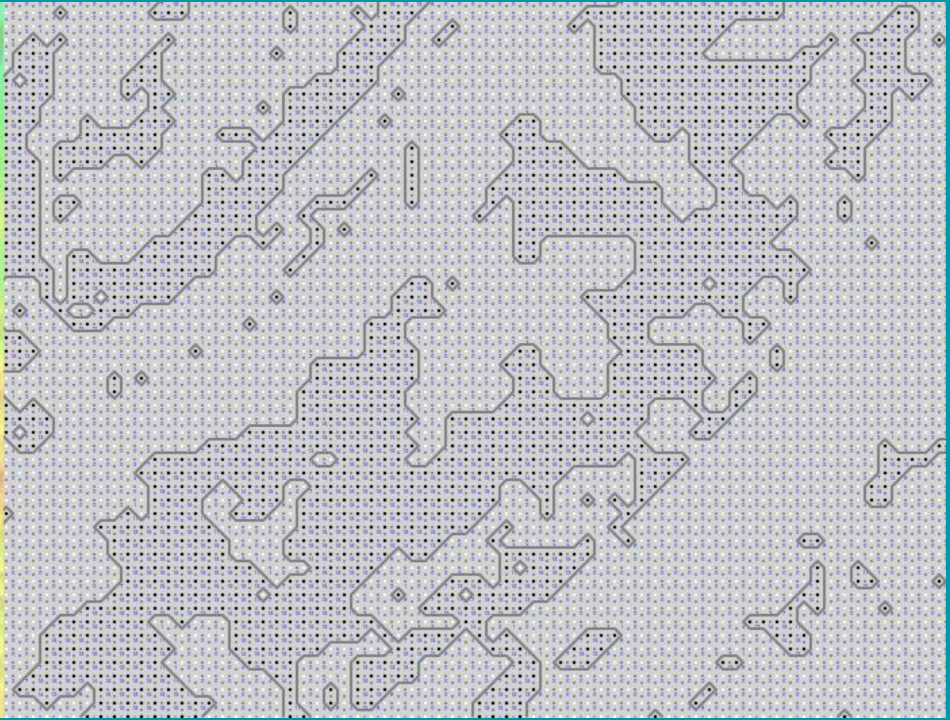
Applications

CT Scan

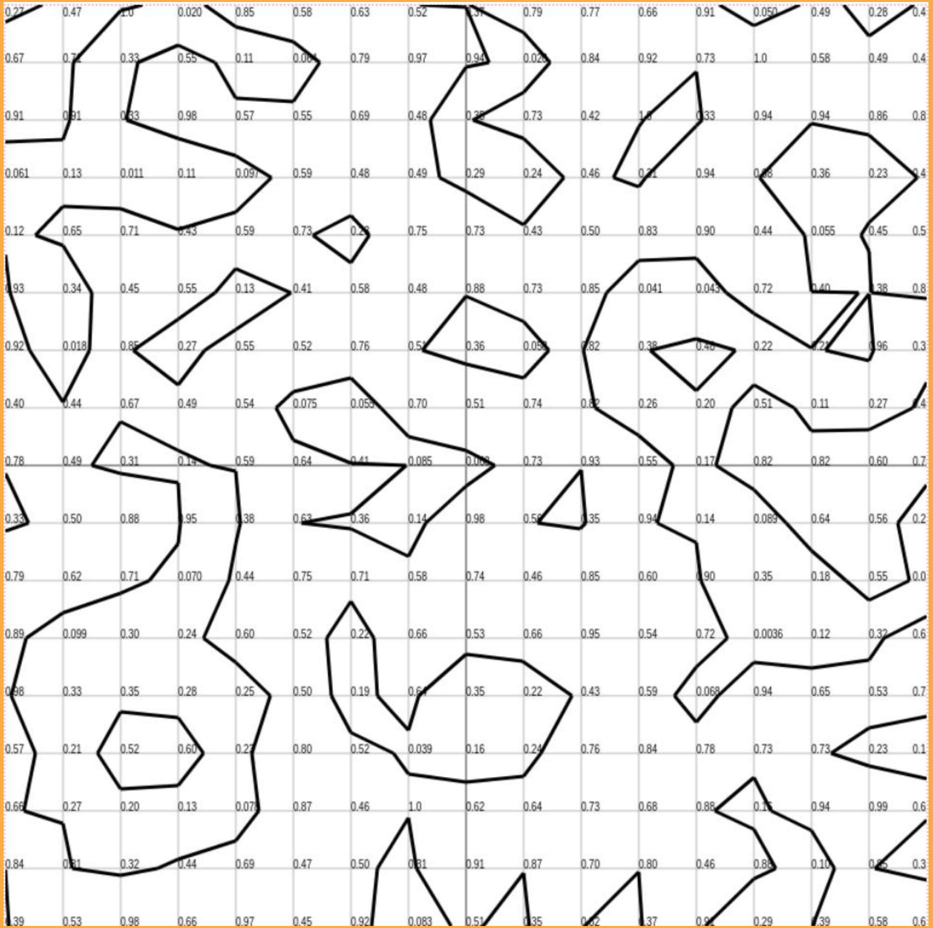

MRI Scan

To draw contours and display iso surfaces





3D Terrain Generation



Marching squares is a graphics algorithm which generates contours in a 2-dimensional scalar field.

Working Principle for 2D

To approximate a given shape,

1. Assume a hypothetical grid around the shape
2. Now each square has a part of the shape (which is nothing but a bunch of lines)
3. We approximate the shape in each square and add them together

Each gridpoint will be assigned a value (boolean or bound values)
So each square will have a tuple of 4 values

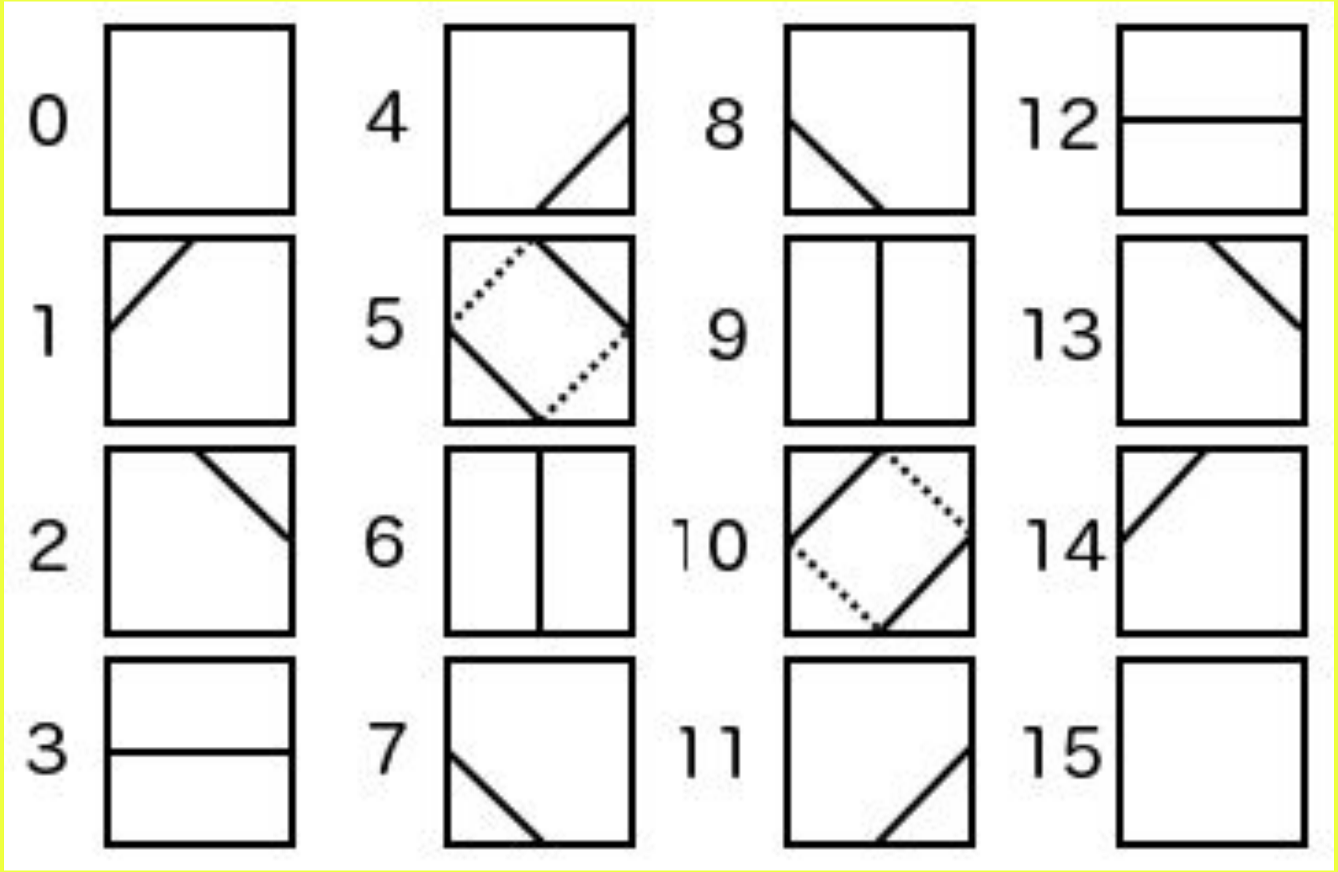
1. For a given square,
    a. Assign the square a value based on its corresponding tuple
    b. According to a lookup table, the value will be mapped to a particular shape/line
2. This is done for each square encompassing the bigger shape

Algorithm 1: The Marching Squares Algorithm.

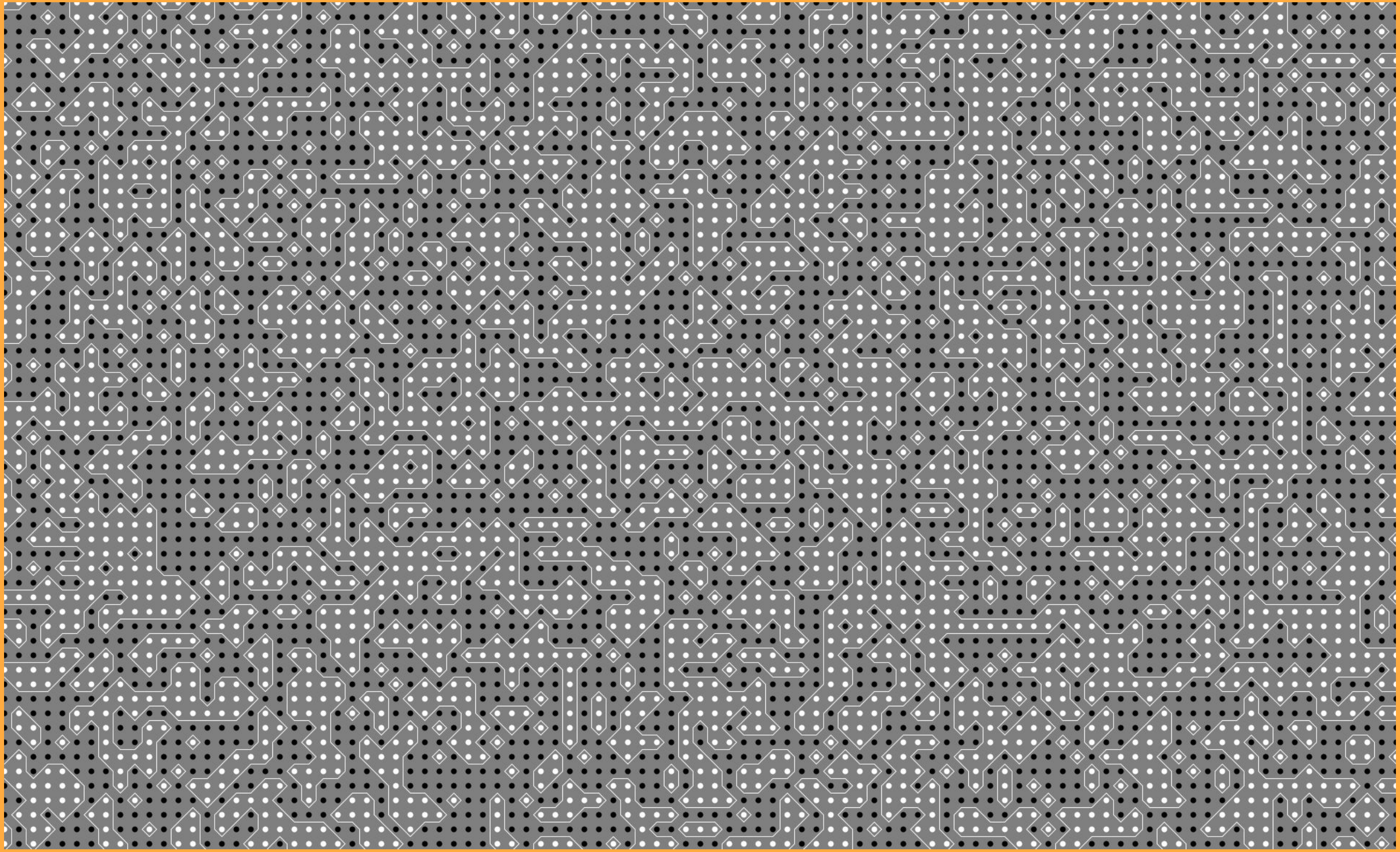
```
Input: $G$ is a $m \times n$ matrix of scalar values.
       stepX, stepY is the sampling resolution.
       $\sigma$ is an isovalue.
Output: A set $\gamma$ of contour lines.

Function MarchingSquares($G$,$m$,$n$,$\sigma$,stepX,stepY) is
    $F$, coord, $p$, $q \leftarrow$ SampleGrid ($G$,$m$,$n$,$\sigma$,stepX,stepY);
    $\gamma \leftarrow$ March ($F$,coord,$p$,$q$);
```

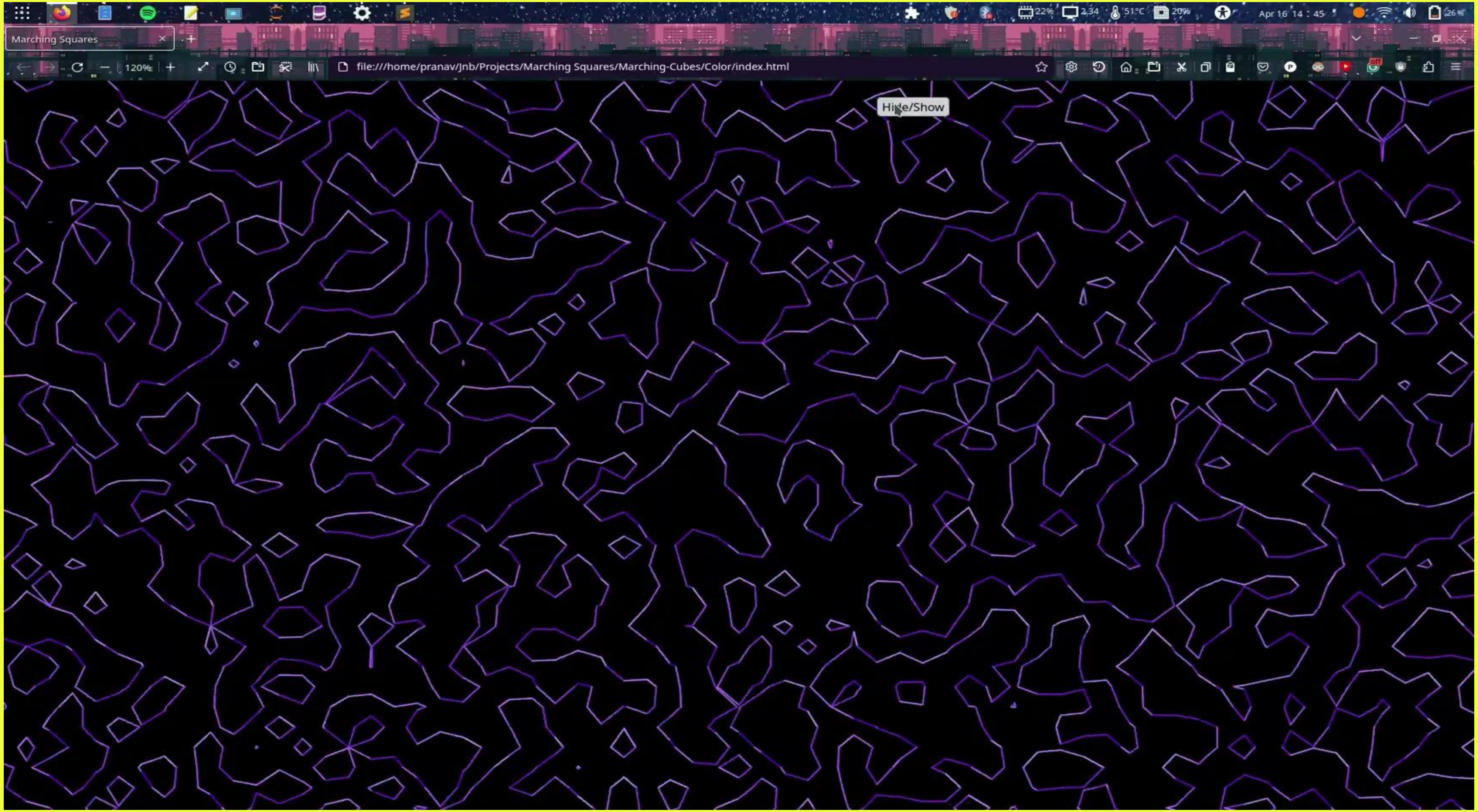
Lookup Table (for Boolean values)



Contouring done on a random static image



MidPoint Approach	Linear Interpolation Approach
The Endpoints of the line are the midpoints of the sides of the points	The endpoints of the line is interpolated according to the value of the points
More Blocky, less accurate	Less Blocky, more accurate
Less Computation	More Computation


Marching Squares
120%
file:///home/pranav/Jnb/Projects/Marching Squares/Marching-Cubes/Color/index.html
Hide/Show
Apr 16 14 : 45

Video Link

Types of Contours:

1. Isolines: line following a same value (called isovalue)
2. Isobands: filled areas between isolines

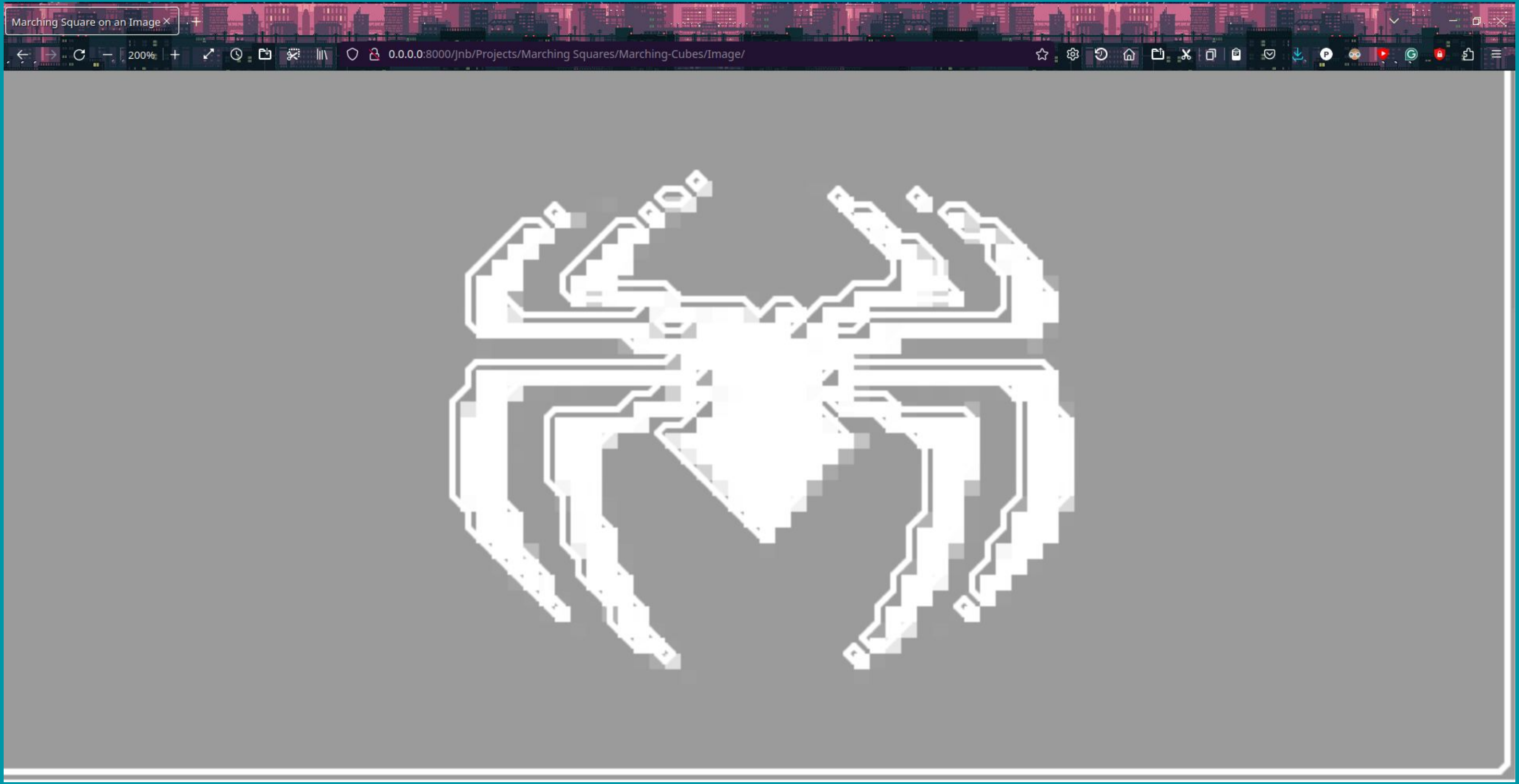
Each gridpoint will have a particular value derived from input
To map them into boolean values or within a certain value, we make use of an **isovalue**

One of the popular methods of assigning values to squares is to encode the tuple of boolean values into 4-bit number and then lookup the shape table.

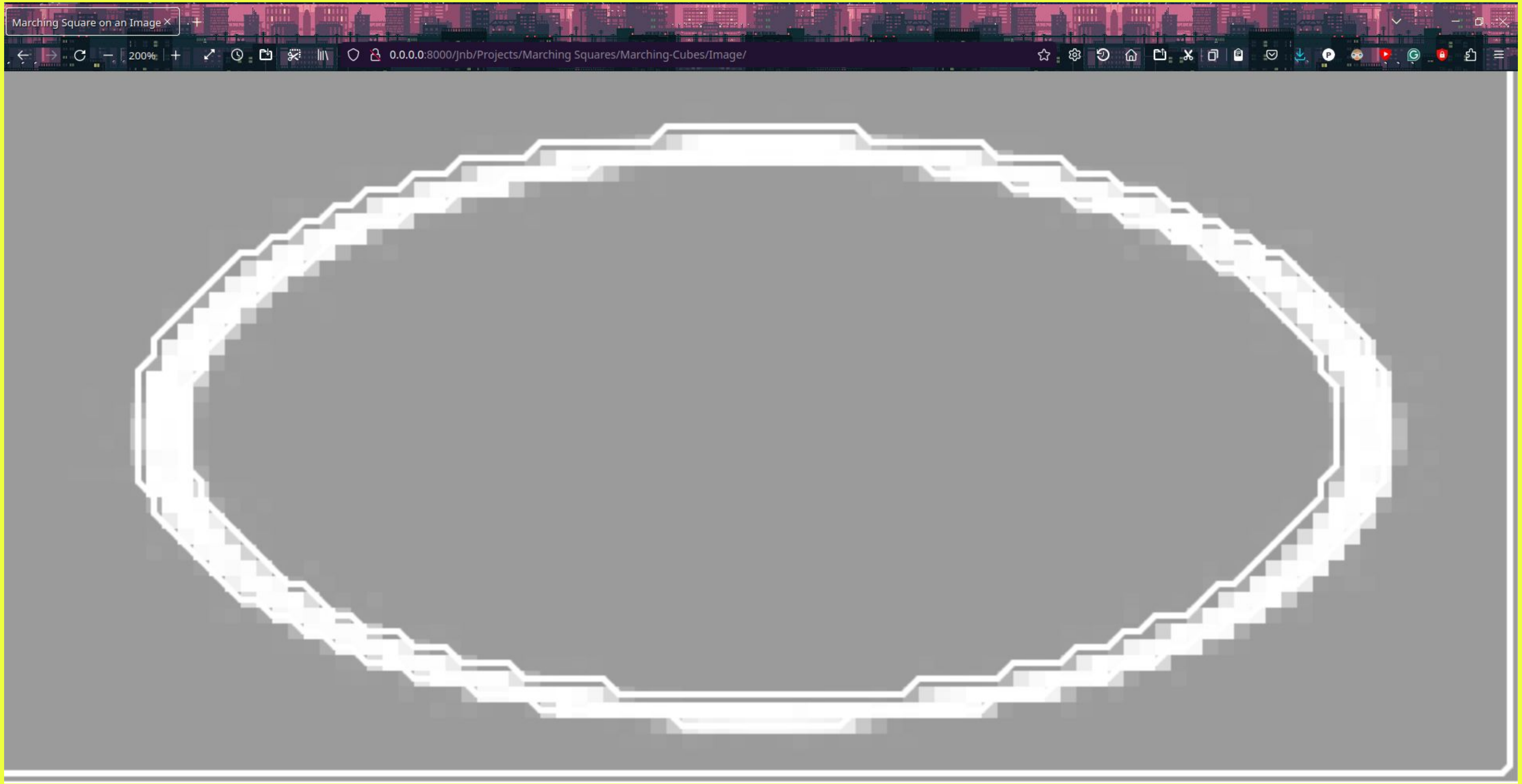
Later, for linear interpolation, we can make use of the original values of the grid points

Same principle applies for Triangular (Meandering Triangles), Tetrahedral and Cubic Algorithms (Marching Cubes)

Approximating an image (1)


Marching Square on an Image
200%
0.0.0.0:8000/Jnb/Projects/Marching Squares/Marching-Cubes/Image/

Approximating an image (2)


Marching Square on an Image
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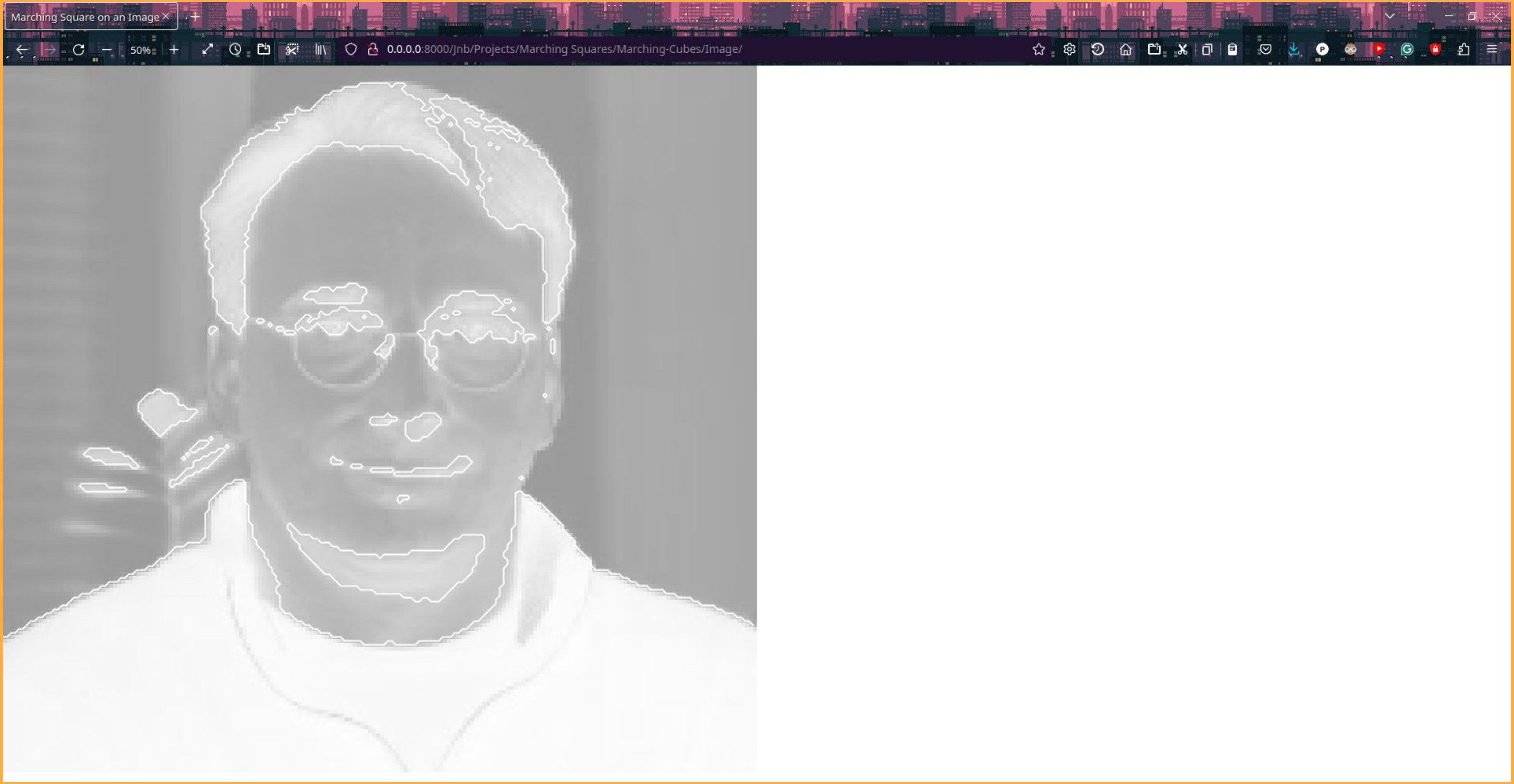
Approximating an image (3)


Marching Square on an Image
50%
0.0.0.0:8000/Jnb/Projects/Marching Squares/Marching-Cubes/Image/

Some Potential Speedups

Easily Parallel - each unit is completely independent from the other

1. Multithreading
2. Usage of GPU
3. Caching the interpolated results

Thank You