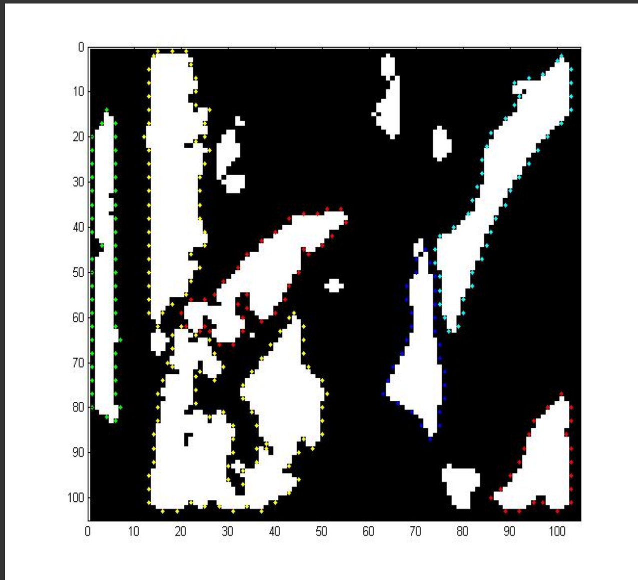


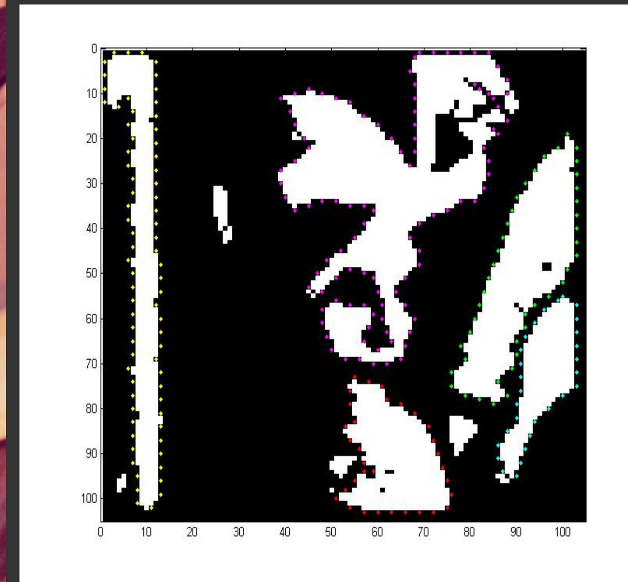


# Boundary Detection in Noisy Images

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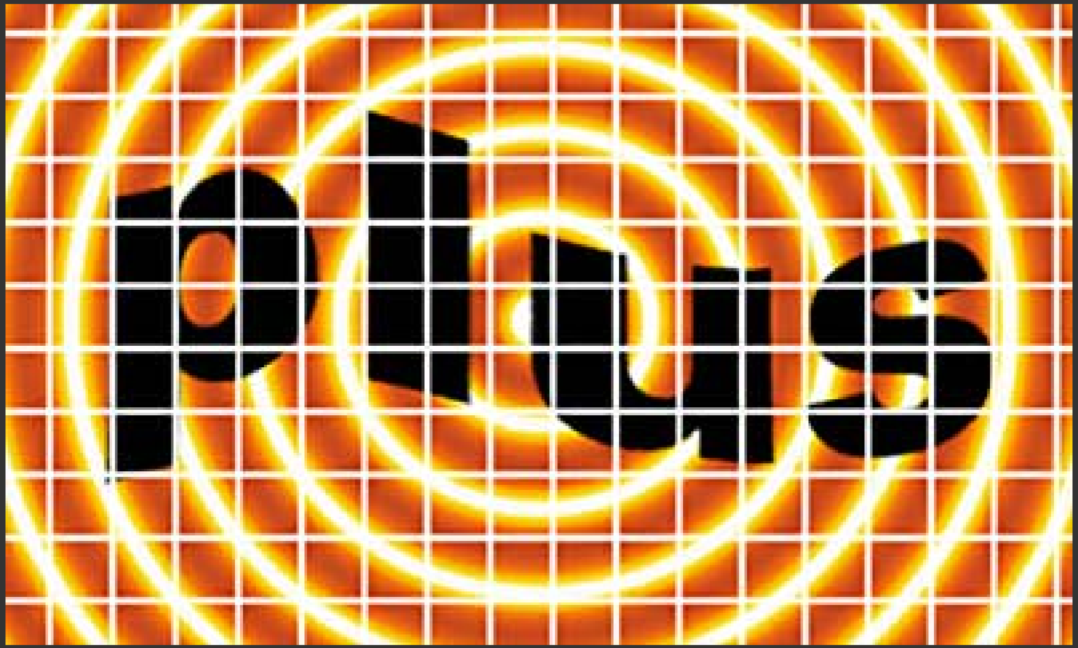
# Intro to Image Processing

**- MathWork's Matlab product:**
**The Image Processing Toolbox**
**- Applications in computer vision, motion analysis, biometrics**
**- Segmentation & edge-finding**


**Dr. Lai's mission for us:**

Find the boundaries of similarly patterned areas in noisy pictures and output them for denoising by spline triangulations.

# Common techniques for segmentation




- Histogram-based
- Clusters
- Region-growing

Gradient-based regions
Contrast peaks and valleys

All such techniques are not directly intended to be used in noised-and-denoised images.

The Berkeley Segmentation Engine

# Whereas we are dealing with this:

# What's the best way to find significant regions in a *noisy* image?

**Image requires additional cleaning**

**Boundary point-collecting**
- Crawling (edge-finding)
- Box-centers (region-growing)
- Iterating over both black and white thresholded images

**Remove redundancy in boundary chains**

**Remove isolated points**

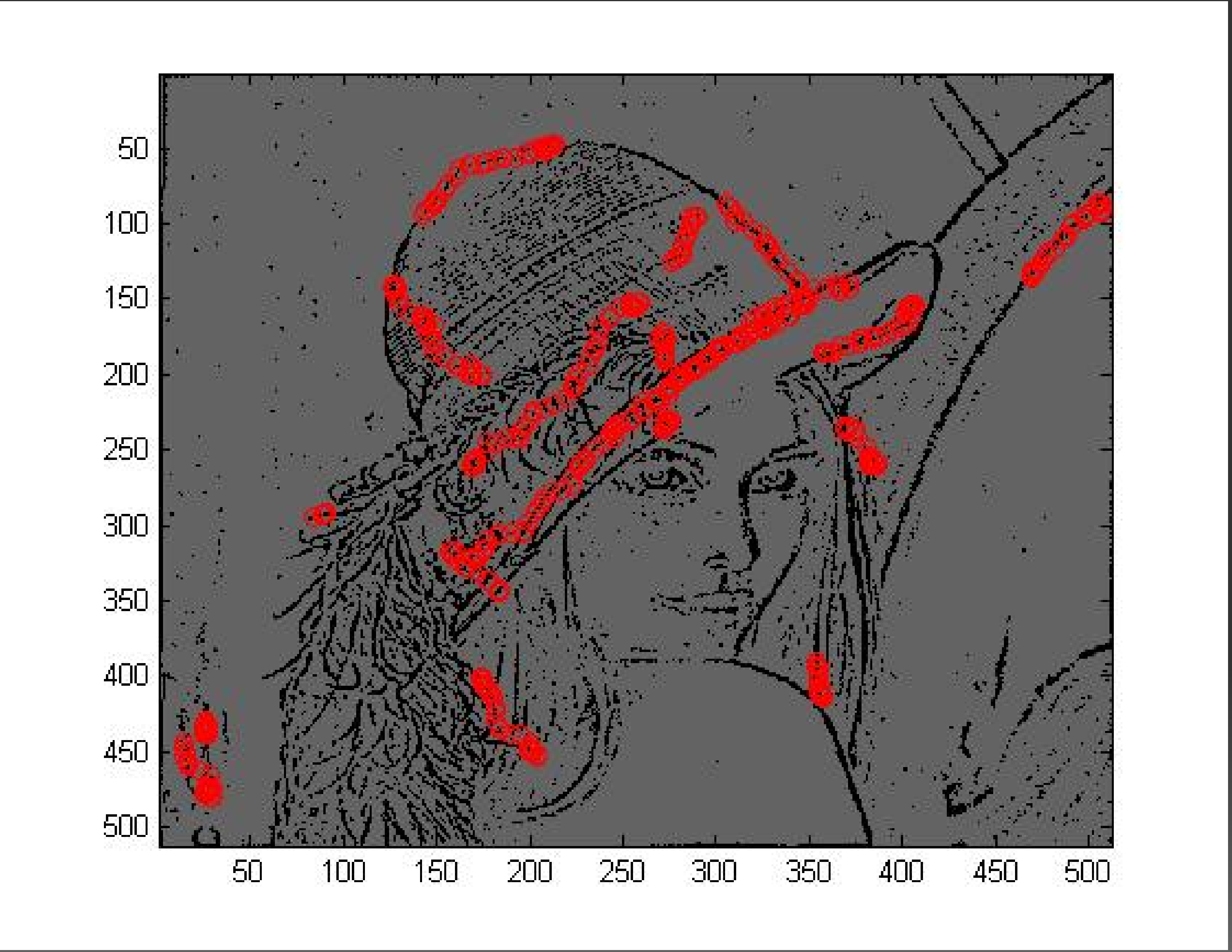
**Order the boundary points**

# First attempt - Edge crawling

```
function [X,Y]=hasNeighbor(A,D,x,y,C1,C2)
    % hasNeighbor takes a binary matrix A and an ordered vector of
    % points around the current point in the crawl.

    S=size(A);
    % default X, Y vals in case no neighbor is found
    X=[x]; Y=[y];
    test=0; % breakout value
    % check for black points in list of D coordinates
    for c=1:length(D)
        %index-out-of-bounds test
        if (D(1,c)<1 || D(1,c)>S(2) || D(2,c)<1 || D(2,c)>S(1))
            ;
        else
            if A(D(2,c),D(1,c))>1
                test=1;
                for i=1:length(C1)  %loop checks for hitting previous point
                    if (C1(i)==D(1,c) && C2(i)==D(2,c))
                        test=0; % prevent breakout, point has already been found
                    end
                end
                if (test==1) % not a repeated point
                    X=[X, D(1,c)]; % store coordinates
                    Y=[Y, D(2,c)];
                end
            end
        end
    end
```

Enmeshedness, recalculating slope, forking directions; it was generally a mess.

# Trial and error - Edge-crawling



# Trial and error - Cleaning the image

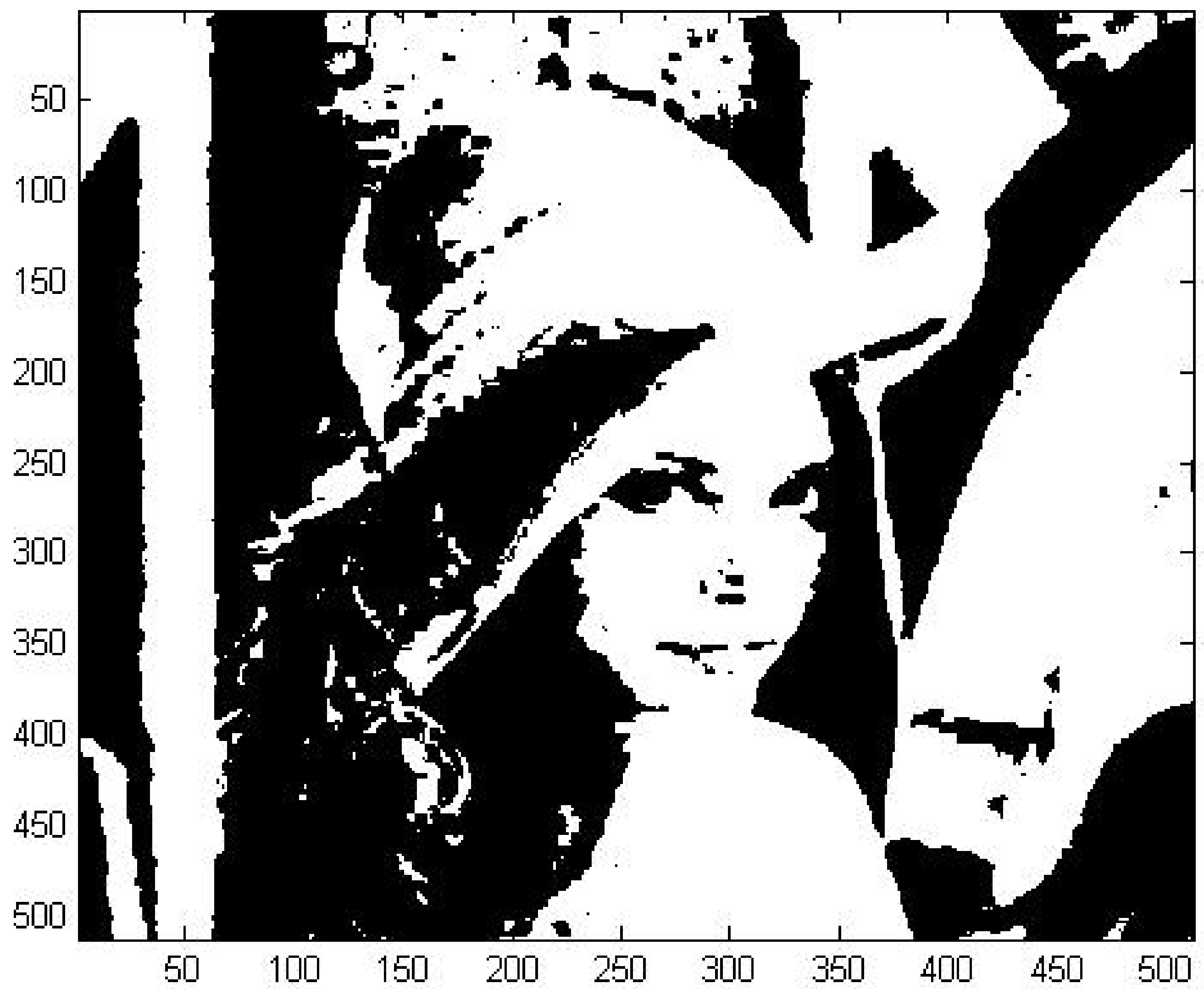
**Thinning**
- How?
- How much?

**Setting thresholds**
- Handpicked
- Automatic
- Both black and white thresholds

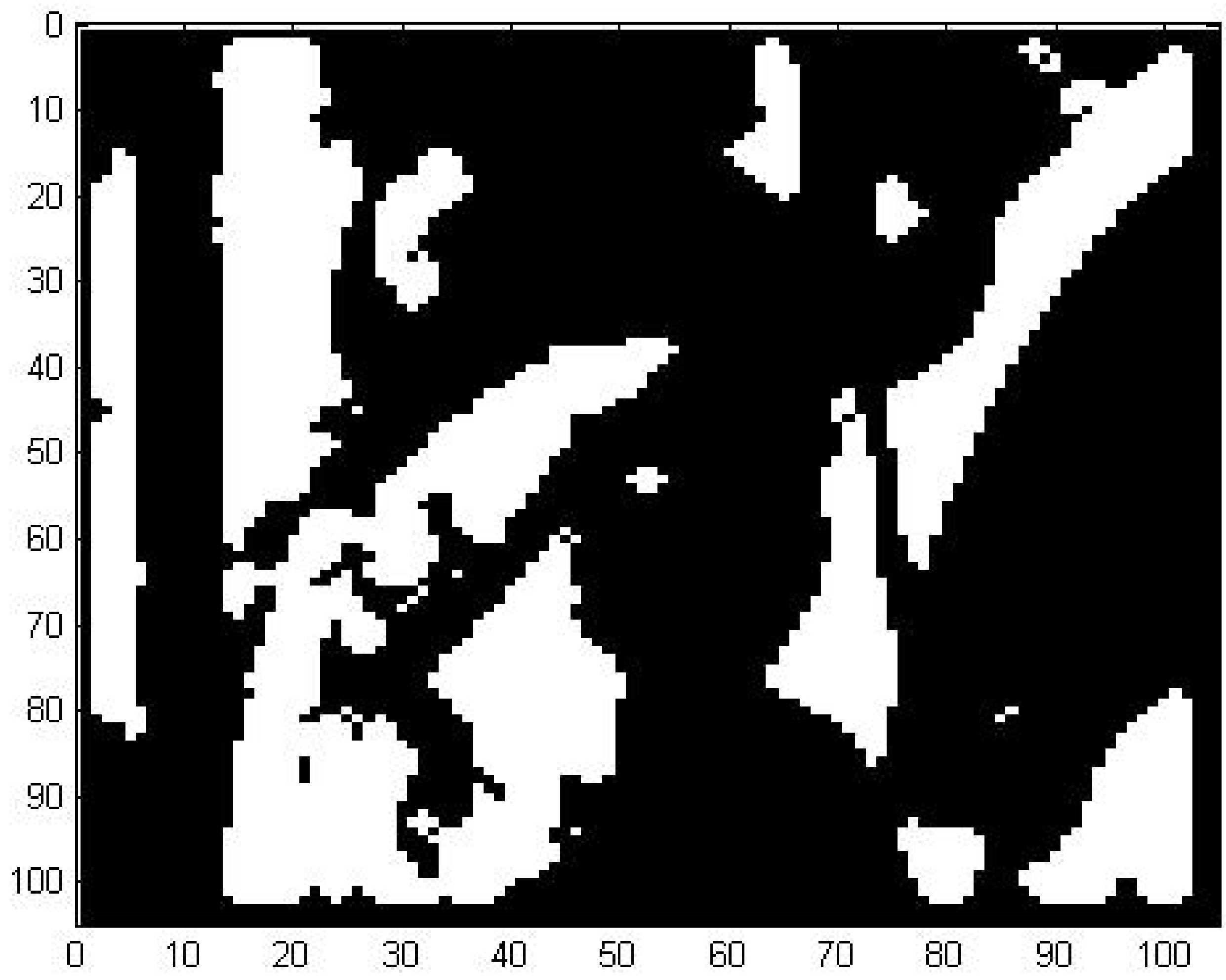
**"Compressing" each 5 x 5 macropixel**
- Identifying solely white areas of the image
- Form regions from these adjacent white areas

Original *Lena* image

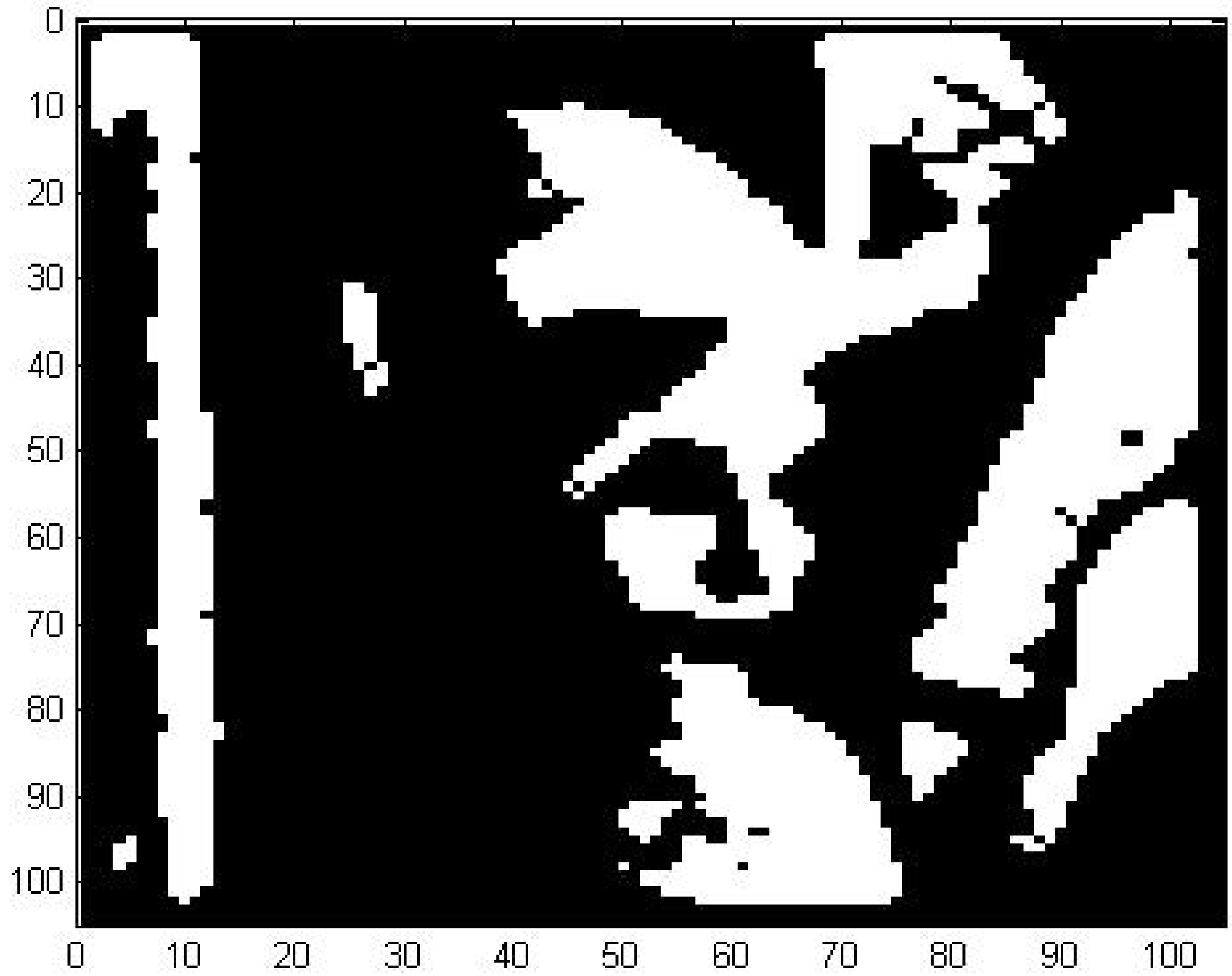

Noised, then denoised *Lena*




*Lena* after thresholding




"Compressed" image of box centers

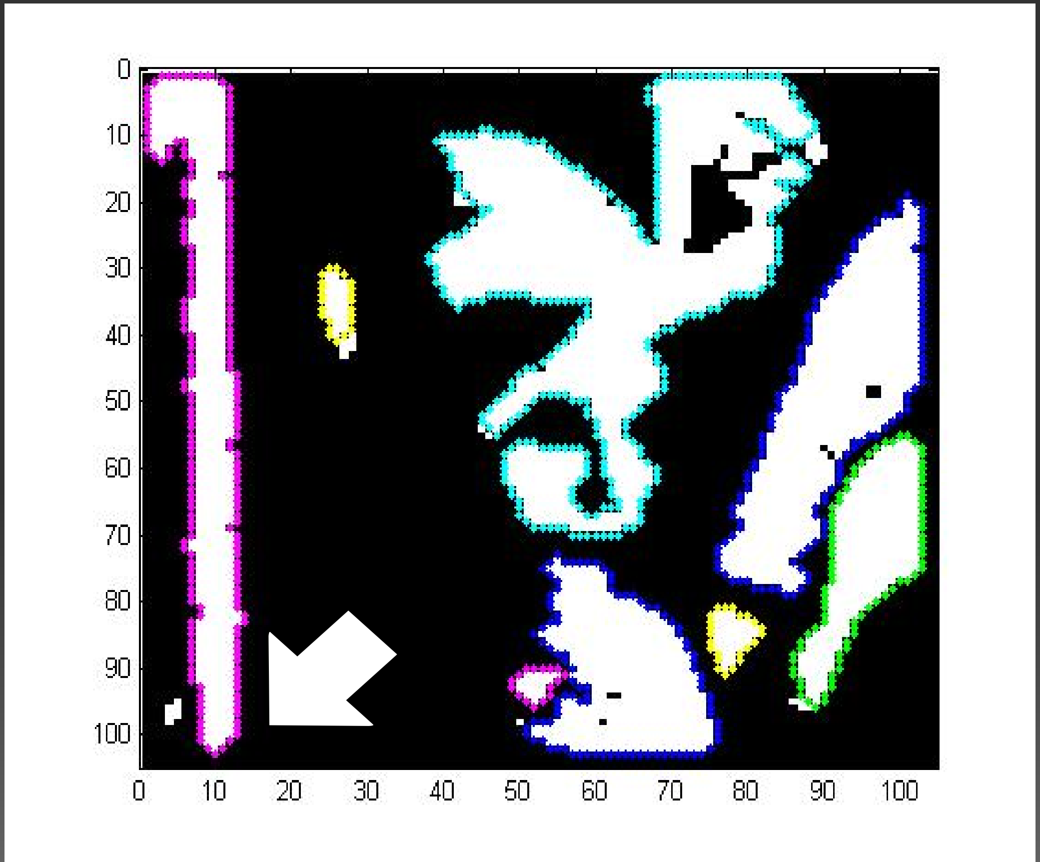


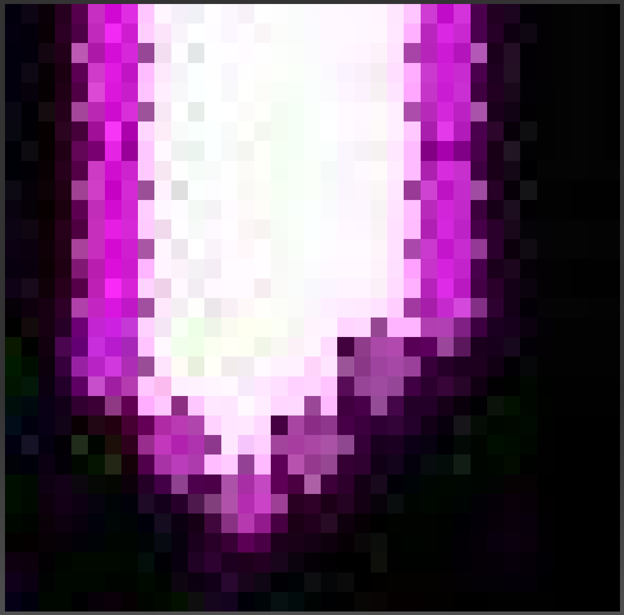

"Compressed" image of box centers (inverted)

# What do we do with these?

Clearly we use these to find the boundaries of the white areas.

We programmed an unseeded region-growing method, where we iterate through every white pixel in the compressed image, initiating a crawl for other white neighbors.



# Removing redundancies

```
function C = cleanChains(C)
% removes redundancy in each chain of cell array C
    Schain=size(C);
    for i=1:Schain(2)
        chain=C{i};
        S=size(chain); count=1;
        while(count<=S(2))
            J=find(chain(1,:)==chain(1,count) & chain(2,:)==chain(2,count));
            j=2;
            while (j <= length(J))
                chain(:,J(j))=[0; 0];
                j=j+1;
            end
            c1=nonzeros(chain(1,:));
            c2=nonzeros(chain(2,:));
            chain=[c1'; c2'];
            count=count+1;
            S=size(chain);
        end
        C{i}=chain;
    end
```

First step of the chain-aggregating process

# Clean isolated points from the chains

```
function E=removeIsolatedPoints(C)
% remove isolated boundary points in each chain of
% the cell array C
    S=size(C);
    E=cell(1,S(2));
    for i=1:S(2)
        chain=C(i);
        SChain=size(chain);
        for j=1:SChain(2)
            if (hasNeighbors(chain,chain(:,j)) <= 1)
                chain(:,j)=[0;0];
            end
        end
        c1=nonzeros(chain(1,:));
        c2=nonzeros(chain(2,:));
        E(i)=[c1'; c2'];
    end
```

If a point has one or no white neighbors, it's irrelevant.

# Ordering of boundary points

```
function finalChain=orderChain2(chain)
% orders the closed boundary coordinates of each cell
% in the cell array 'chain'
    cells=1; SC=size(chain); finalChain={};
    while (cells <= SC(2))
        C=chain{cells};
        orderedChain=C(:,1);
        initPoint=C(:,1);
        point=[-1;-1];
        count=1;
        alreadyChecked=initPoint; % for backtracking
        SChain=size(C);
        while (count < SChain(2))
            if (count==1)
                C(:,1)=[];
                point=initPoint;
            end
            if (count==3)
                C=[initPoint C];
            end
            isntNew=1;
```

```
% down
J=find(C(1,:)==point(1,1) & C(2,:)==point(2,1)-1); %find neighbor
if (isempty(J)==0) % neighbor exists?
   orderedChain=[orderedChain C(:,J)]; % add neighbor to orderedChain
   point=C(:,J); % set new point
   alreadyChecked=[alreadyChecked point]; % add to list of checked
   C(:,J)=[]; % delete found point from unorderedChain C
   isntNew=0; % point's been found, no need to check other neighbors
end

if (isntNew==1)
   %downright
    J=find(C(1,:)==point(1,1)+1 & C(2,:)==point(2,1)-1) ;
    if (isempty(J)==0)
       orderedChain=[orderedChain C(:,J)];
       point=C(:,J);
       alreadyChecked=[alreadyChecked point];
        C(:,J)=[];
       isntNew=0;
    end
end

% etc.
```

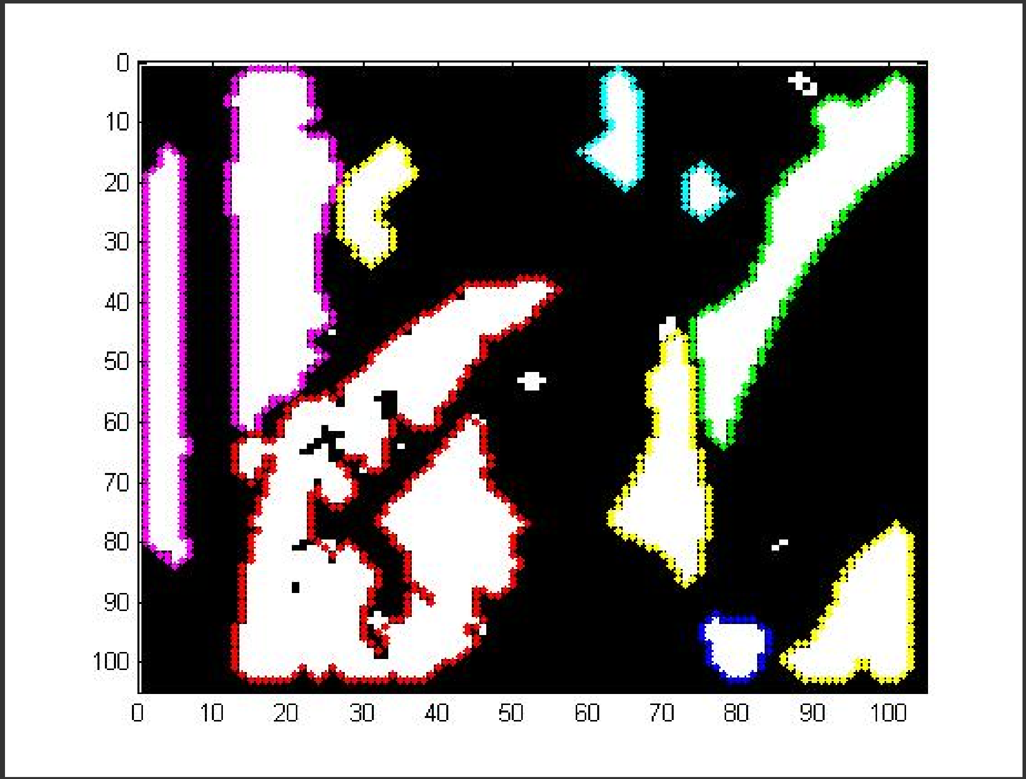
```
            if (initPoint(1,1)==point(1,1) && initPoint(2,1)==point(2,1))
                break;
            end

            % should we go back?
            if (isntNew==1 && isempty(alreadyChecked)==0)
                SChecked=size(alreadyChecked);
                point=alreadyChecked(:,SChecked(2));
                alreadyChecked(:,SChecked(2))=[];
            else
                count=count+1;
            end
        end

        finalChain{cells}=orderedChain; % add chain to cell array
        cells=cells+1; % increment cell array counter
    end

```

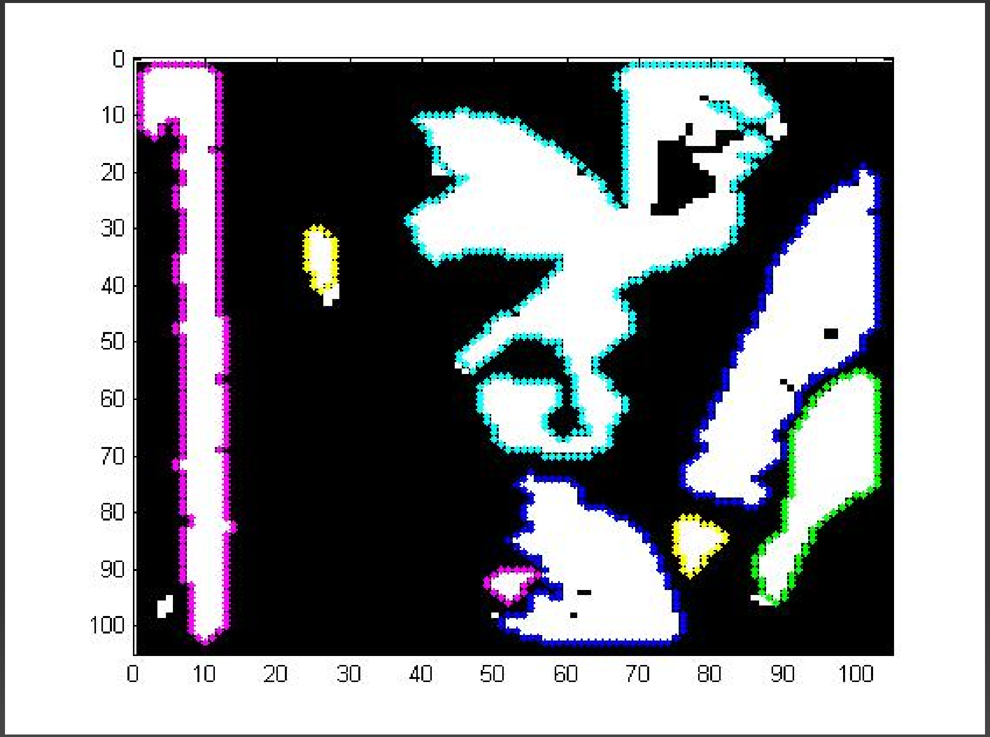
End of the while loop, crawling around boundary

# Thin Chains

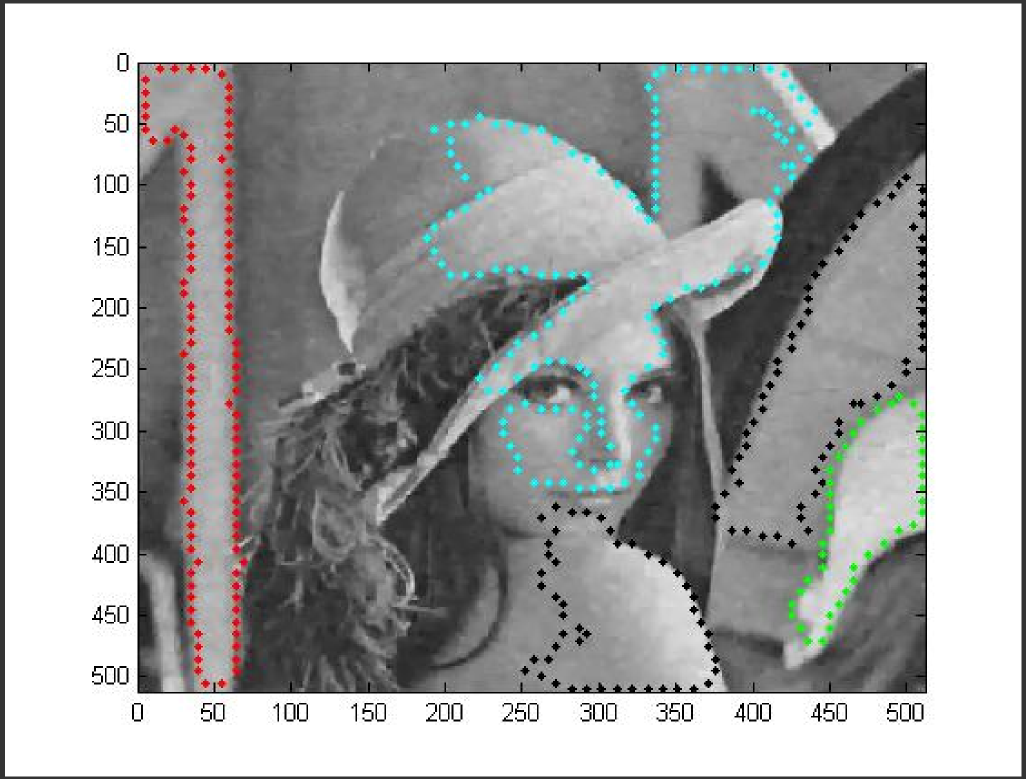
```
function C = thinChains(chain, pointspacing)
 thinchain={};
 sChain=size(chain);
 for i = 1:sChain(2)
        c=chain{i};
        thin=[;];
        for j=1:pointspacing:length(c)
            thin=[thin, c(:,j)];

        end
        thinchain{i}=thin;
 end

 C=thinchain;
```

We look at every other point (representing a five-by-five section of the image) in the chain in order to make the triangulation process faster.




Resulting regions from both thresholds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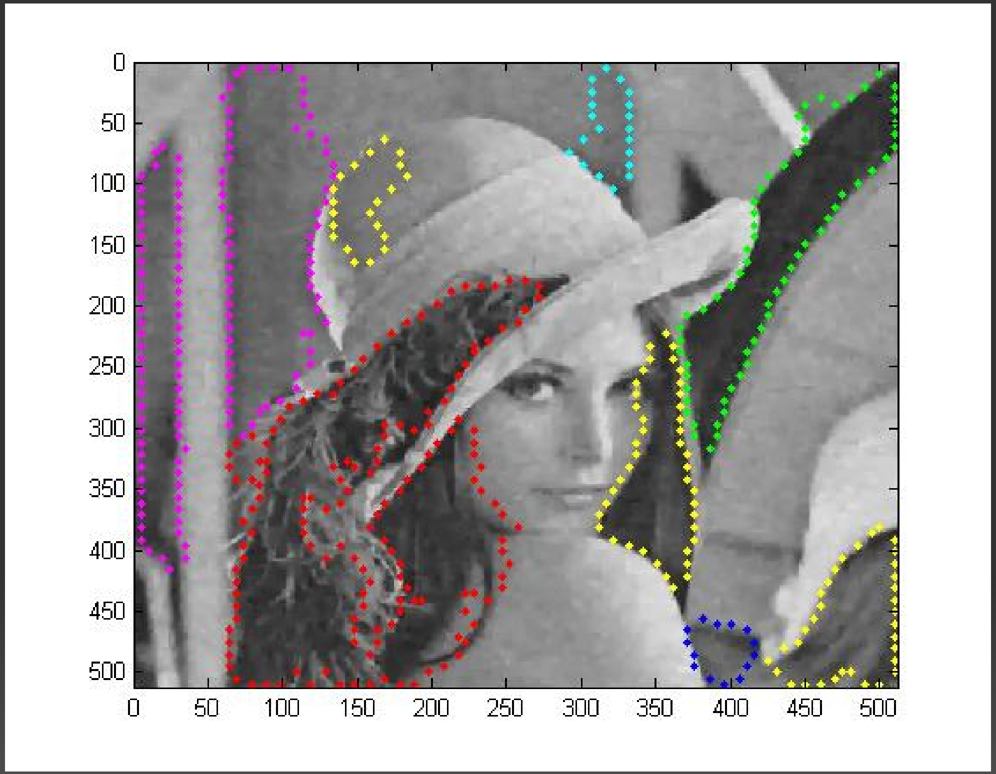
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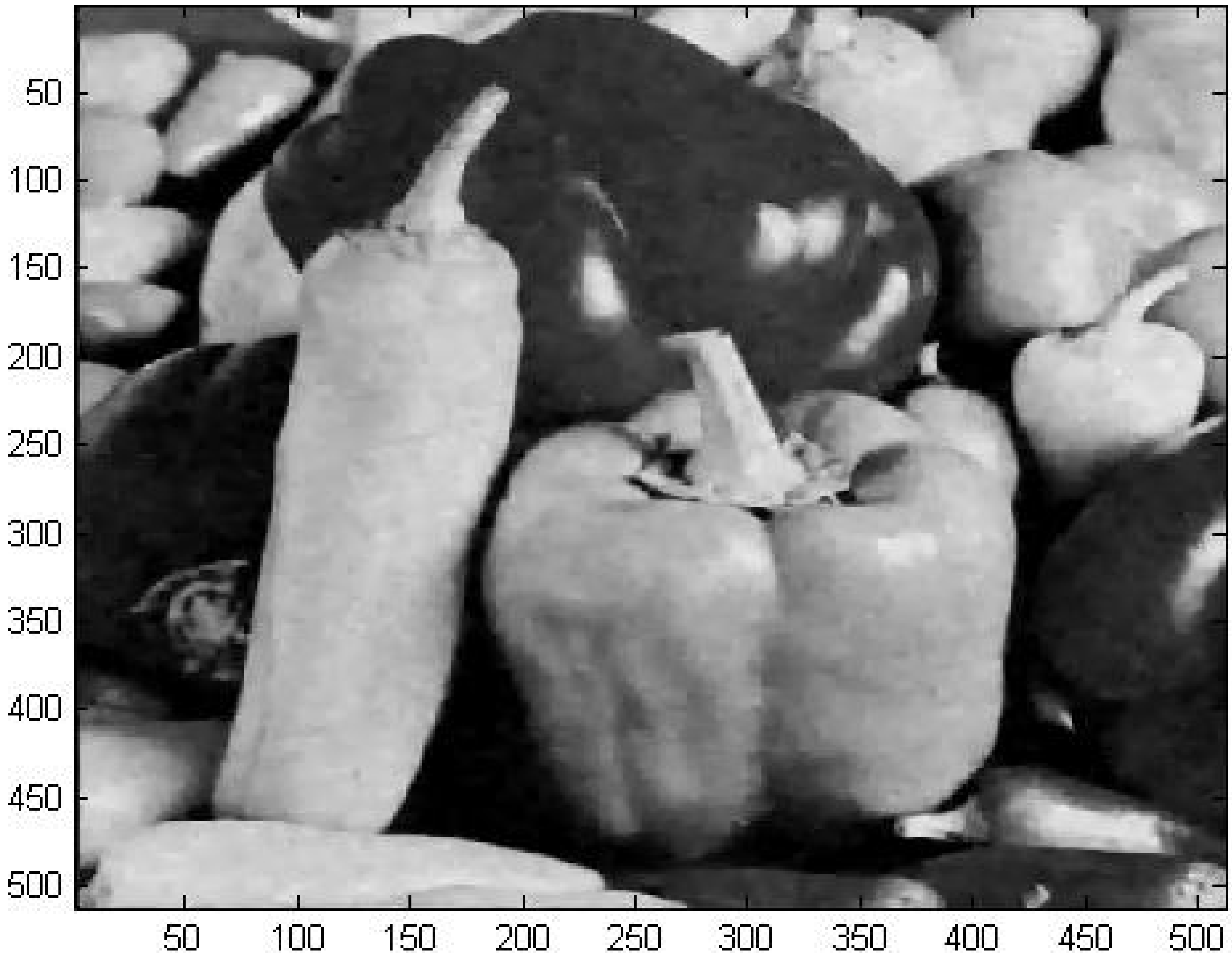

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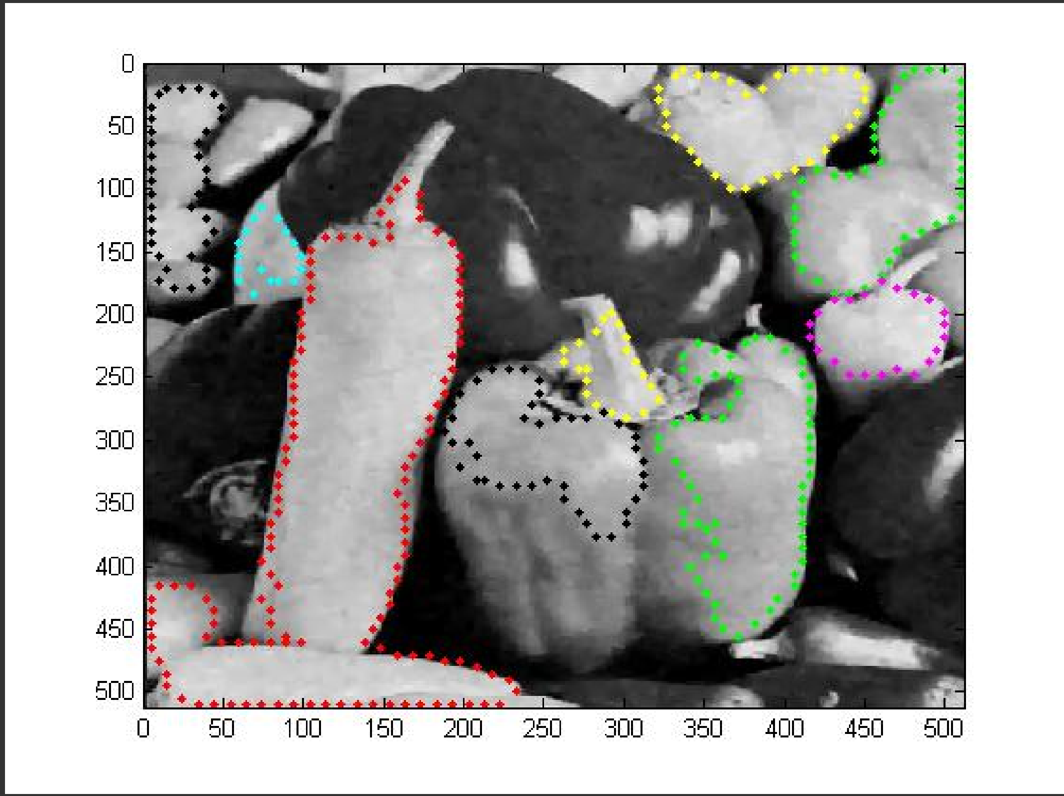
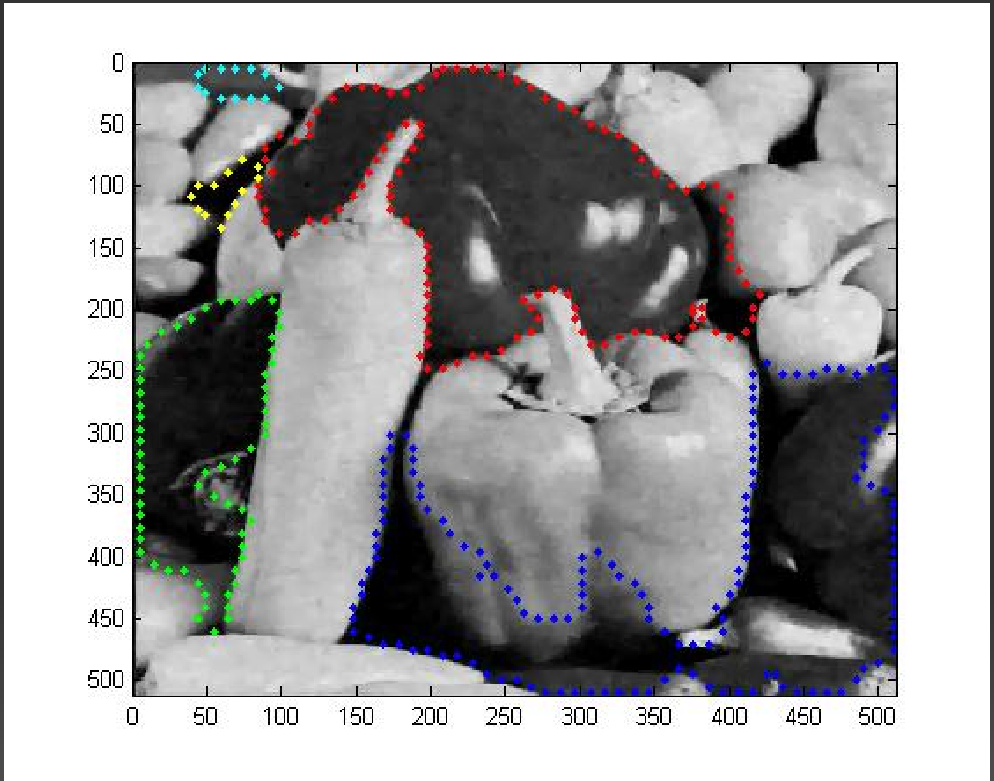


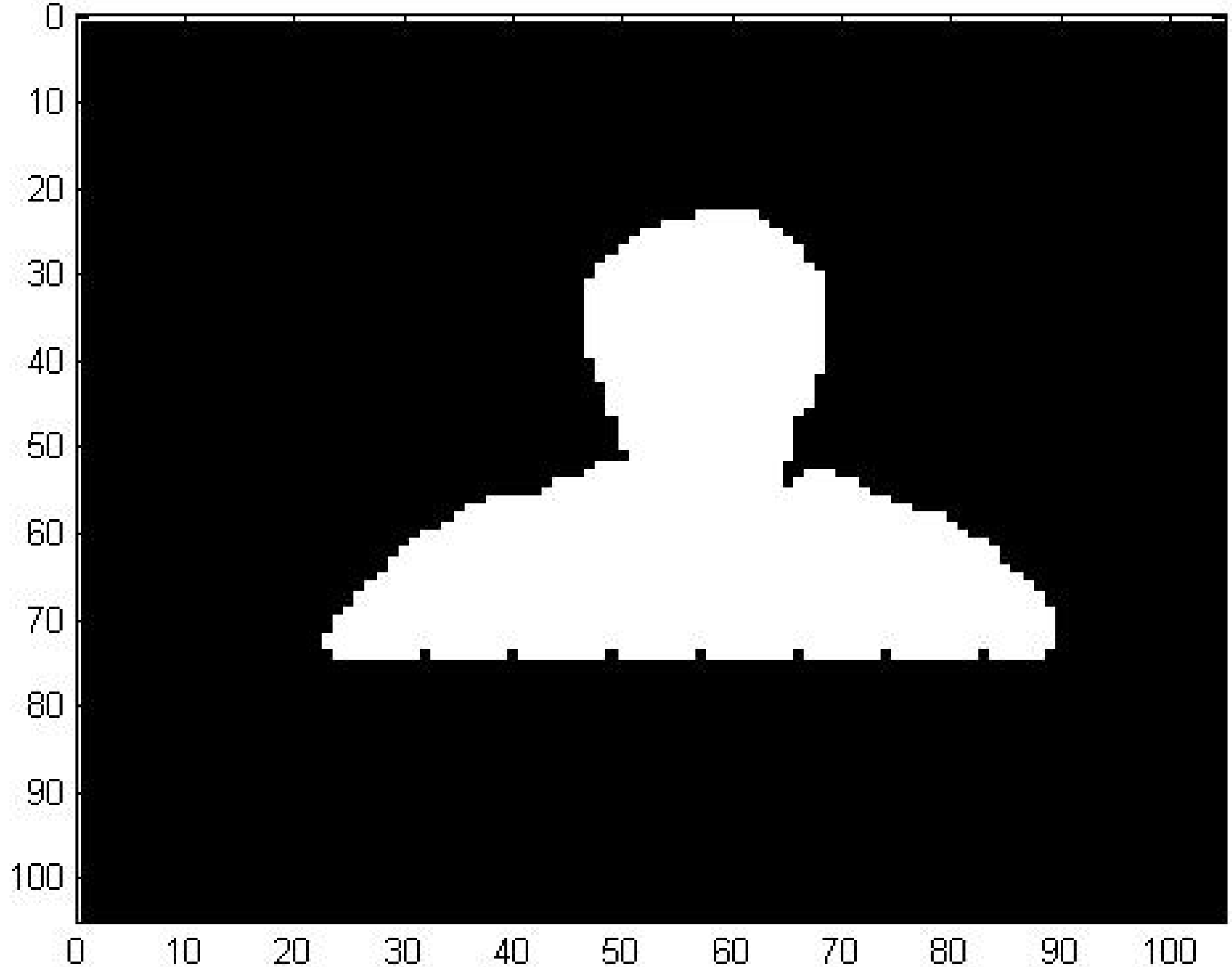

Resulting regions

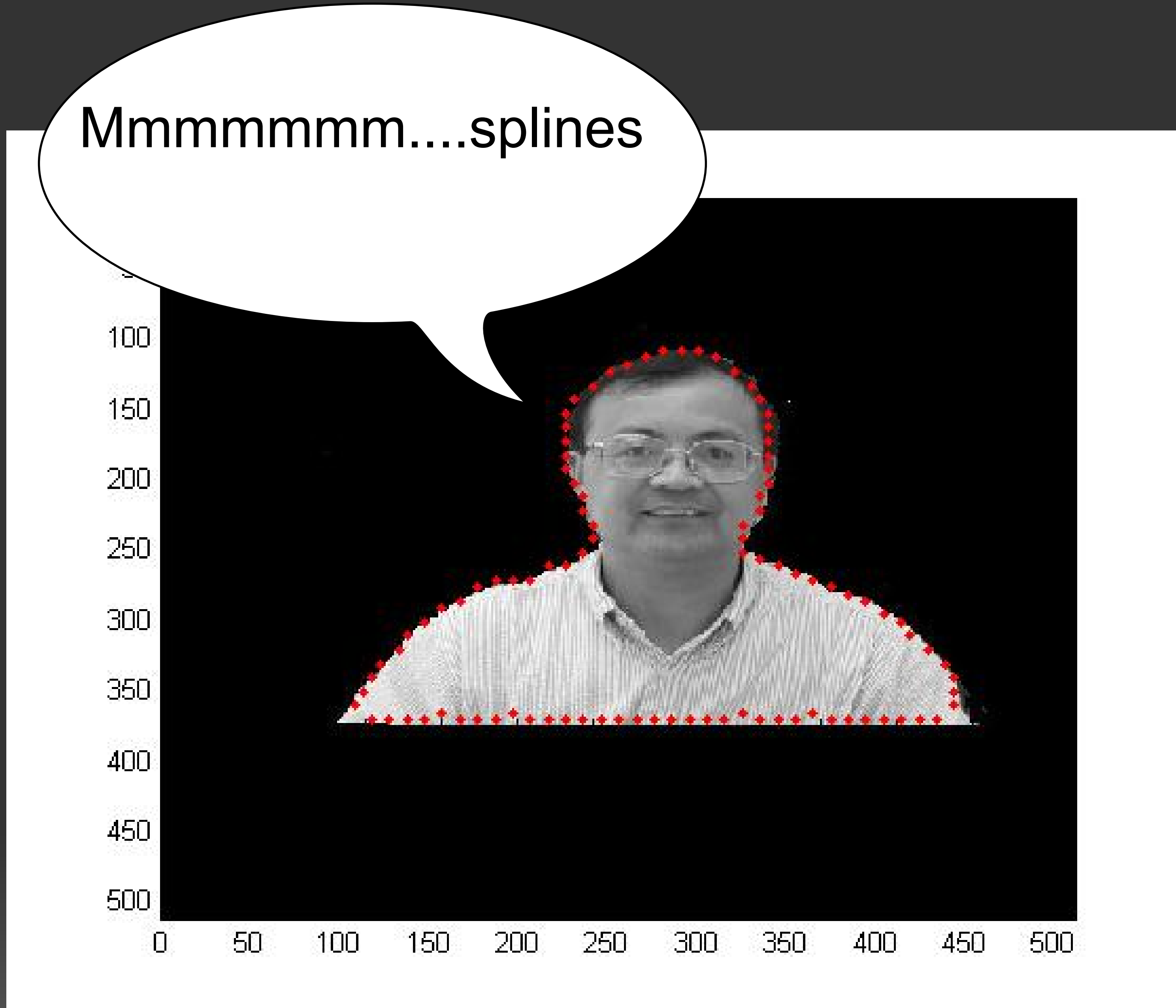
Demonstration of our method on *F-16* photo, extra-noisy *Lena*

# What more can be done

- Better thresholds (completely automatic)
- Better **clean**
- Circles, as opposed to blocks
- Different block size
- Color images
- 3-dimensions

# Who is it?






Thank you, Dr. Lai!


Edges are
tough.