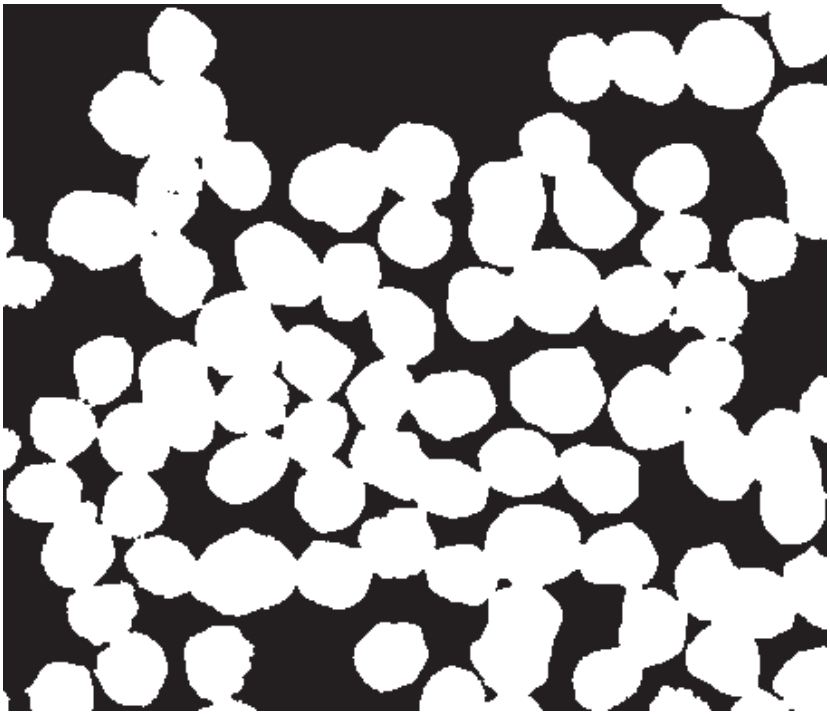
Watershed Transform

*Excerpted from the **Steve on Image Processing** blog.*

Watershed segmentation can be a powerful technique for separating overlapping objects. This blog post addresses the common challenges when using watershed segmentation and how a few preprocessing steps can make this "advanced" technique easy to use and understand.

A support call came in this week from a customer trying to use the watershed function in Image Processing Toolbox™ to segment this image:

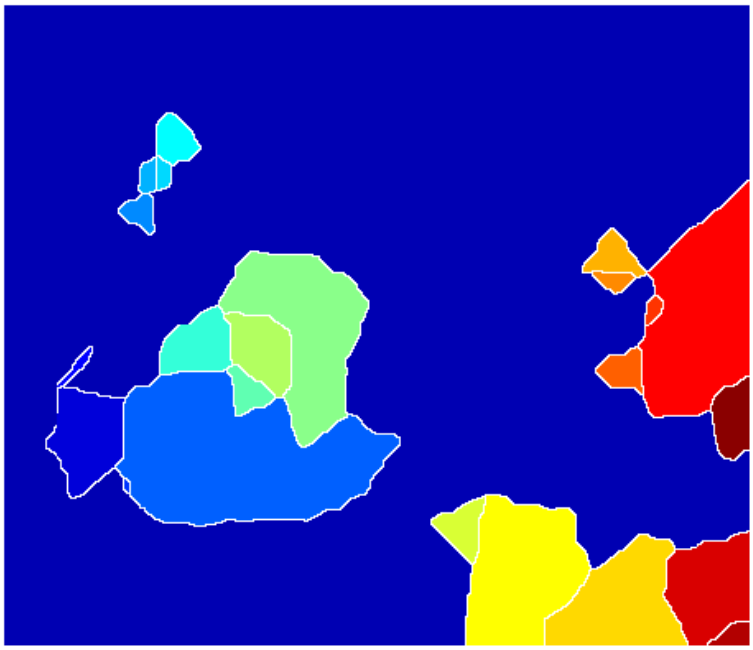


The complaint was that watershed did not produce a good segmentation.

Today I want to show how to use watershed to segment this image. Along the way I'll explain the difference between the *watershed transform* and *watershed segmentation*.

First, let's just try calling watershed and see what happens.

```
url = 'http://blogs.mathworks.com/images/steve/2013/blobs.png';
bw = imread(url);
L = watershed(bw);
Lrgb = label2rgb(L);
imshow(Lrgb)
```



When I saw that result, I was puzzled at first. Then I realized what was going on. Let me use `imfuse` to show these two images together, zooming in on one particular blob.

```
imshow(imfuse(bw,Lrgb))
axis([10 175 15 155])
```

The watershed transform always gives you one watershed region for every local minimum (or regional minimum) in the image. These little black "noise spots" are local minima, and so there's a watershed region around each one.

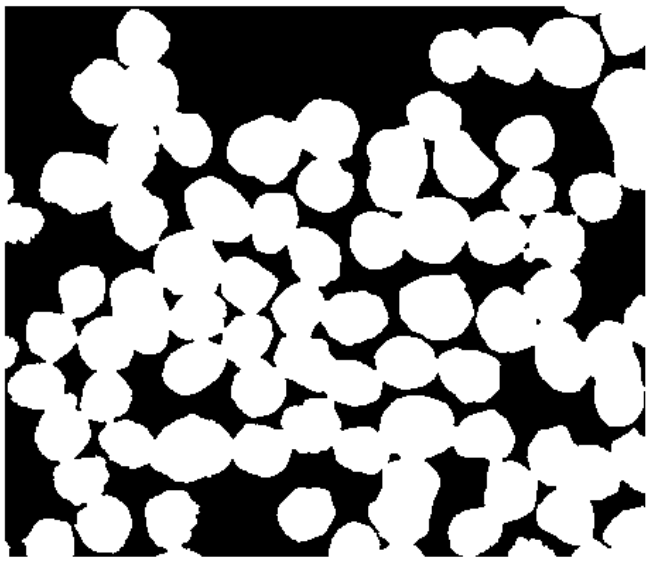
Even if we fill these holes, though, just using the watershed transform by itself is never going to produce the segmentation that the customer was seeking. That brings me to my point about the distinction between watershed segmentation and the watershed transform. *Watershed segmentation* refers to a family of algorithms that are **based** on the watershed transform. Except for very specific cases, the watershed transform isn't a full segmentation method on its own.

Some years ago, I wrote a MathWorks technical article called ***The Watershed Transform: Strategies for Image Segmentation***. It's worth reviewing in order to brush up on the basics. An central concept from the article is this: The key behind using the watershed transform for segmentation is this: **Change your image into another image whose catchment basins are the objects you want to identify.**

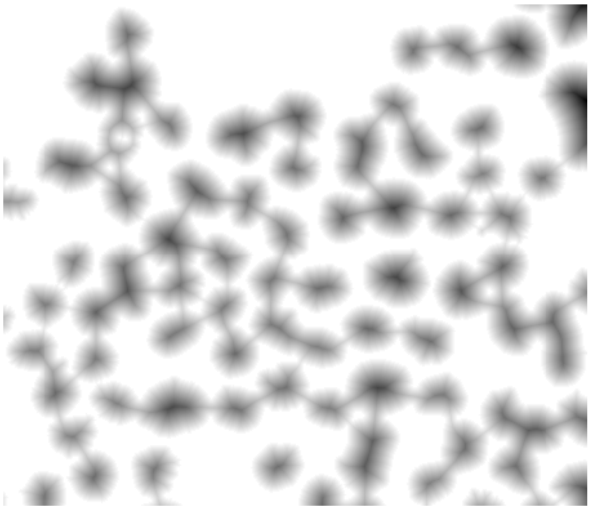
For an image such as this, consisting of roughly circular, touching blobs, the distance transform can be useful for producing an image whose "catchment basins are the objects you want to identify."

Before going to the distance transform, though, let's clean up the noise a bit. The function `bwareaopen` can be used to remove very small dots. It removes them in the foreground, though, so we complement the image before and after calling `bwareaopen`.

```
bw2 = ~bwareaopen(~bw, 10);
imshow(bw2)
```

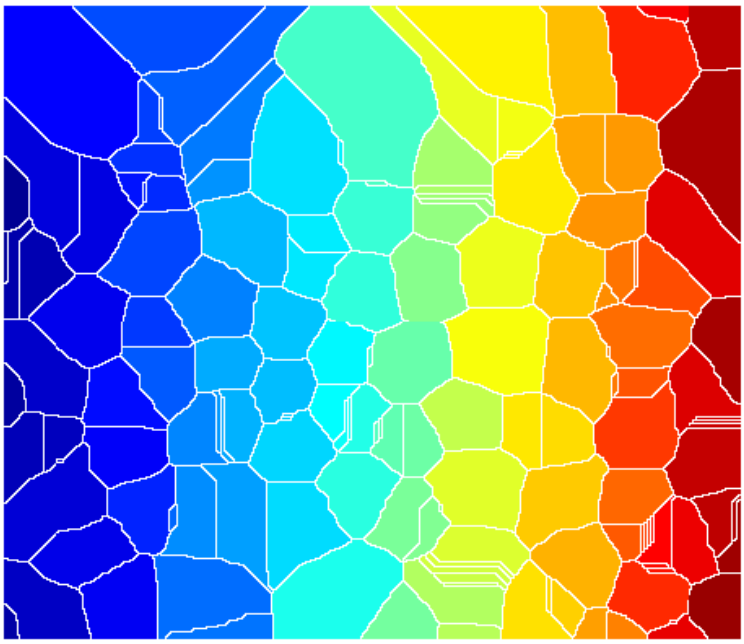


```
D = -bwdist(~bw);
imshow(D,[])
```



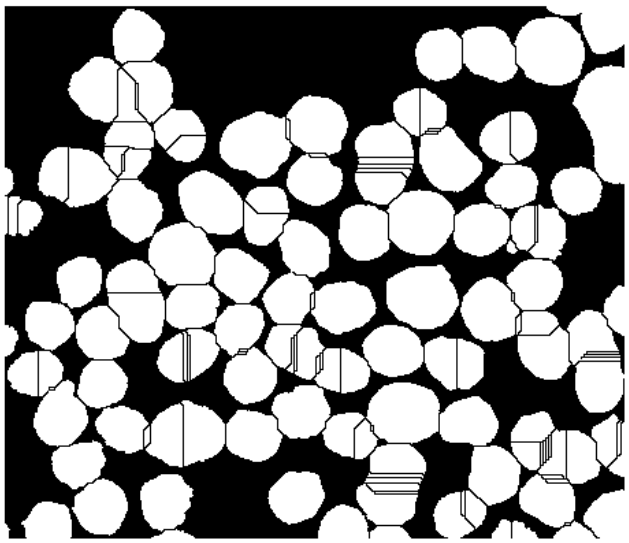
Now we're starting to get somewhere. Next, compute the watershed transform of `D`.

```
Ld = watershed(D);
imshow(label2rgb(Ld))
```



The watershed ridge lines, in white, correspond to `Ld == 0`. Let's use these ridge lines to segment the binary image by changing the corresponding pixels into background.

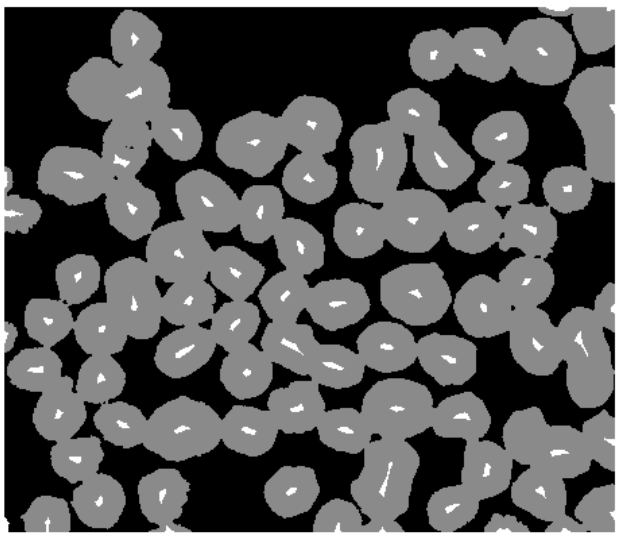
```
bw2 = bw;
bw2(Ld == 0) = 0;
imshow(bw2)
```



The “raw” watershed transform is known for its tendency to oversegment an image. The reason is something I mentioned above: Each local minimum, no matter how small, becomes a catchment basin. A common trick, then, in watershed-based segmentation methods is to filter out tiny local minima using the `imextendedmin` function and then modify the distance transform so that no minima occur at the filtered-out locations. This is called *minima imposition* and is implemented via the function `imimposemin`.

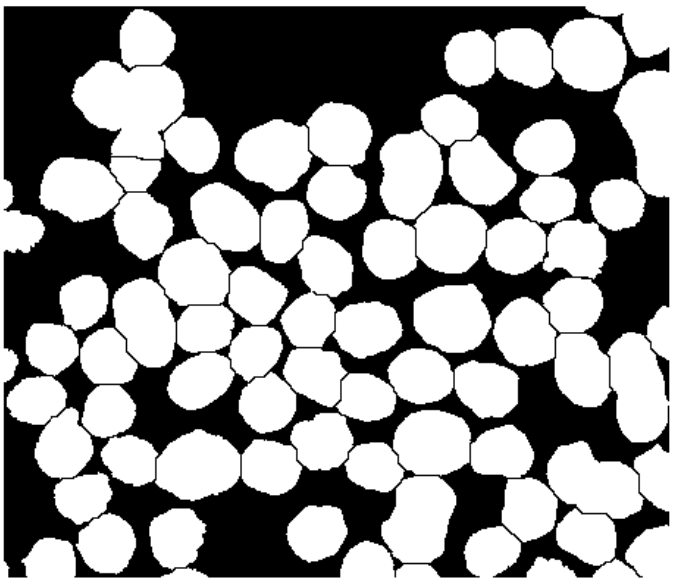
The following call to `imextendedmin` should ideally just produce small spots that are roughly in the middle of the cells to be segmented. I'll use `imshowpair` to superimpose the mask on the original image.

```
mask = imextendedmin(D,2);
imshowpair(bw,mask,'blend')
```



Home stretch, now. Modify the distance transform so it only has minima at the desired locations, and then repeat the watershed steps above.

```
D2 = imimposemin(D,mask);
Ld2 = watershed(D2);
bw3 = bw;
bw3(Ld2 == 0) = 0;
imshow(bw3)
```



That's it!

Learn More About Image Processing

- *Segment Images Interactively and Generate MATLAB Code* (download)
- *SegmentTool: An Interactive GUI for Segmenting Images* (download)
- *The Watershed Transform: Strategies for Image Segmentation* (technical article)
- *Tips and Tricks: Solving a Maze with the Watershed Transform* (technical article)
- *Image Processing Toolbox* (product trial)