# Demonstrating Edge Data Across Multiple Resolution Levels

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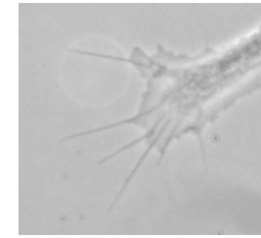
# Outline



- Introduction
- DWT for Edge Detection
- Theory and Experiment
- Conclusion
- References

# Introduction

- Neuroscientists study how filopodia (hair-like structures) that extend from the a neurite grow over time.
  - Currently, uses manual measurement
- Examine multiple octaves of an image, decomposed then reconstructed using the discrete wavelet transform (DWT)
- Show that this technique picks out edges from the background well
- Solution is to automatically detect and measure the filopodia
  - Length
  - Number

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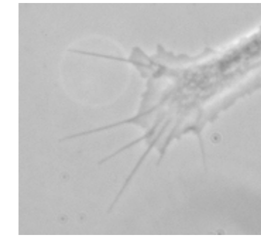
# Introduction



- Human eye immediately distinguishes areas of interest
- Method is automatic, probably because the eye contains some cells that process edges and others that have an averaging effect, much like the DWT
- Successful use of the discrete wavelet transform in edge detection methods [1], [2], [3]

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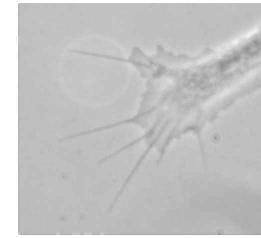
# Neurite



- **Neural image with filopodia and answer edges**
- **640 X 480 pixels**
  - **Correct pixels noted**

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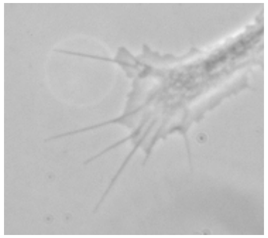
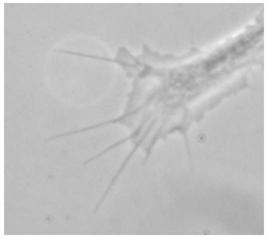
# Traditional Edge Detection



- Automatic Edge Detection
  - Looks for abrupt changes
  - Edges occur at highest first derivative and zero second derivative
    - Low threshold produces false edges
    - High threshold misses edges
  - Edge detectors locate (sharp) changes in intensity
- Better solution needed
  - Wavelet transform splits images into approximation and details
  - Details contain edges
  - We examine edge detecting characteristics of the 2-D DWT
  - Compare to common edge methods for our problem

# Wavelets



- Literally a "little wave”

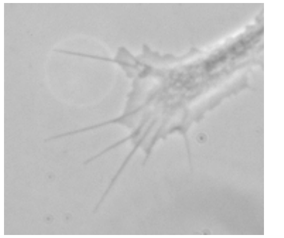
$$W_f(a,b) = \int f(t)\psi(at+b)dt$$

- Giving us

$$\phi(t) = \sqrt{2}\sum_k h[k]\phi(2t-k)$$

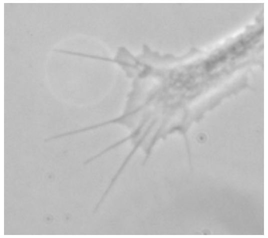
$$\psi(t) = \sqrt{2}\sum_k g[k]\phi(2t-k)$$

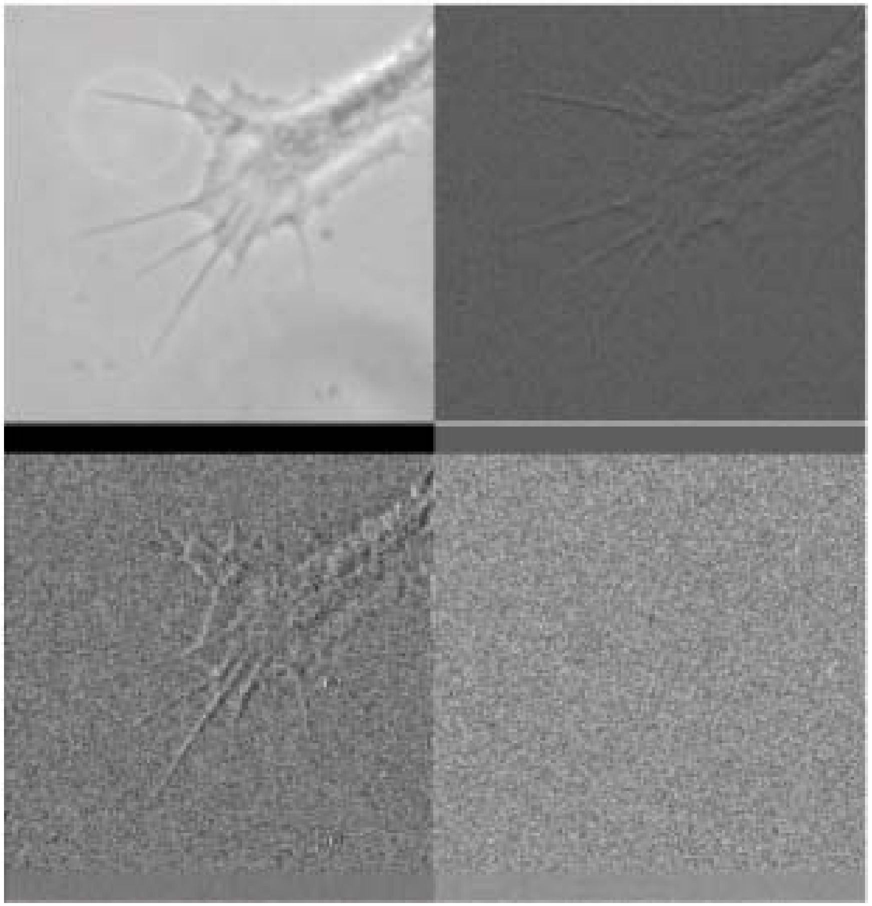
# Wavelets



- The discrete wavelet transform (DWT) decomposes the image
- 3 details and 1 approximation
  - Approximation looks just like the original, only on 1/4 the scale
  - Details separate horizontal, vertical, and diagonal information
- Preserves slow changing aspects in LPF
- Quickly changing parts in HPF
- Edges become sudden changes
- Separated by this process
- Detail images contain edge information.
- Multi-resolution
  - Data flows from one level to next Octave
  - Can be performed recursively

# First Octave





- DWT exploits a self-similarity
- Use the edges that appear at various levels of resolution (octaves)
- Indicates where the important edges of the image exist

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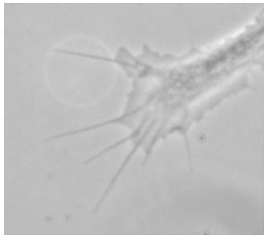
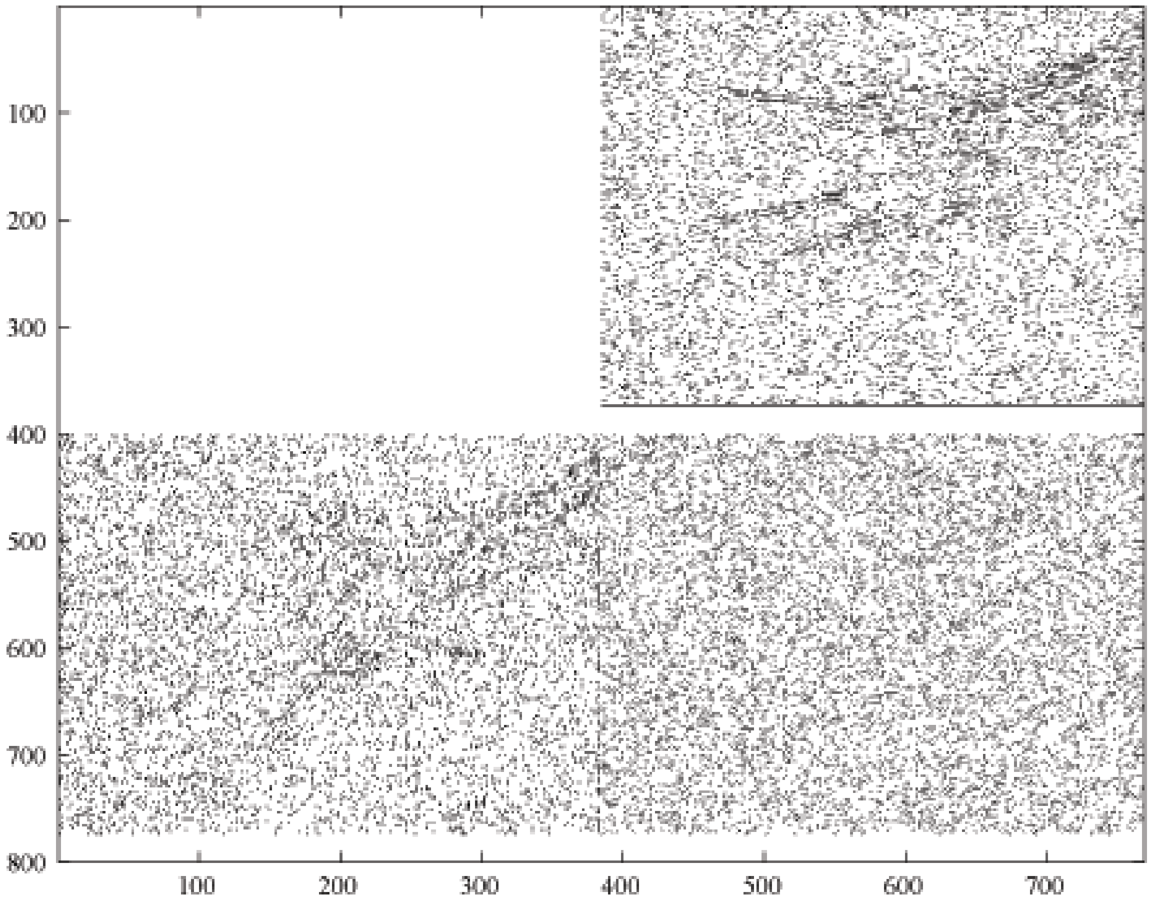
# Octave 1 Sub-details



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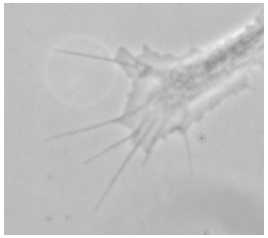
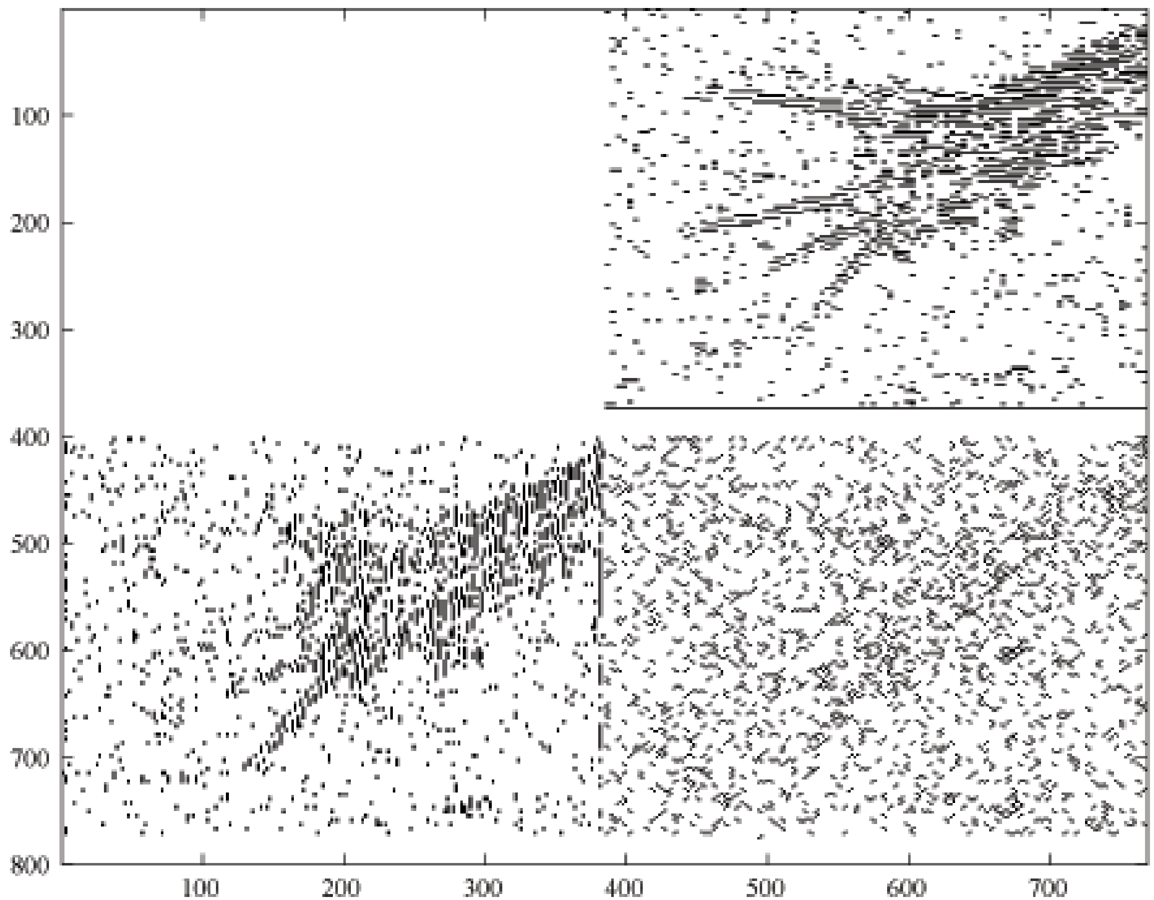
# Octave 2 Sub-details



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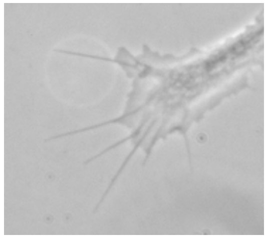
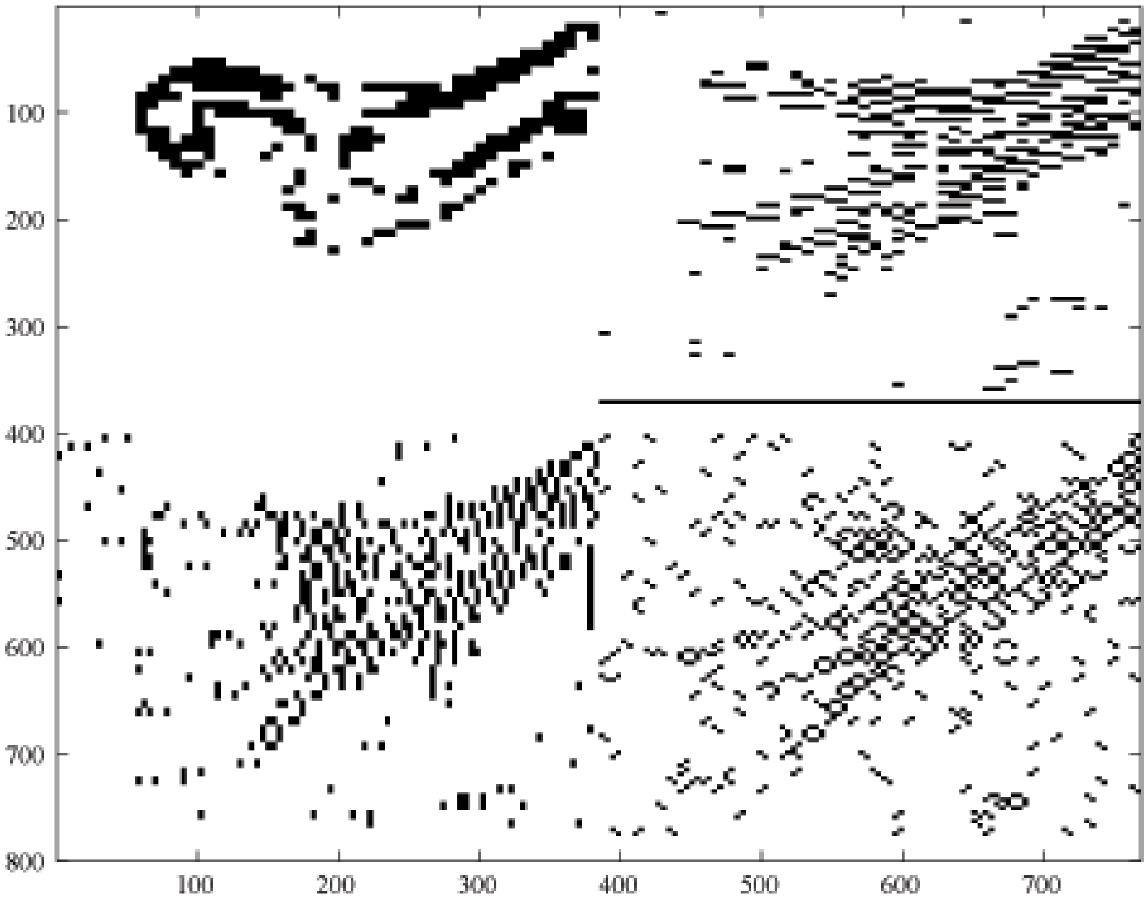
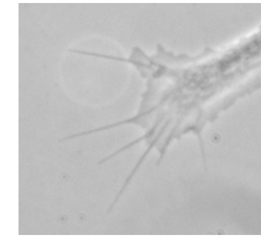
# Octave 3 Sub-details





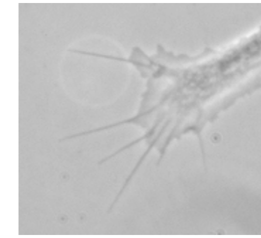
# Reconstructing the Original Image



$$im' = A_3(i, j) + B_3(i, j) + C_3(i, j) + D_3(i,j) + B_2(i, j) + C_2(i, j) + D_2(i, j) + B_1(i, j) + C_1(i, j) + D_1(i, j)$$

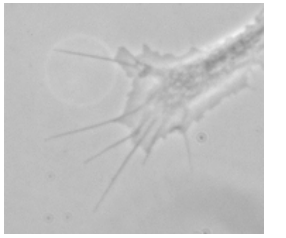
im' – Reconstructed image
i - rows
j – columns
$A_3$ $B_3$ $C_3$ $D_3$ –Synthesize octave 3
$B_2$ $C_2$ $D_2$ – Synthesize octave 2
B1 $C_1$ $D_1$ – Synthesize octave 1

# Maxima and Minima



- Differences between pixels produces the maxima and minima
- Edges of interest (presence of a maxima) is comprised of the largest 10% of values
- Magnitude of these maxima indicates the “strength” (or human-noticeability) of the edges (contrast)

# Conclusion



- The edges of interest appear more and more clearly, as we analyze the image for additional octaves
- Additional octaves do not necessarily add edge information
- Edge information is preserved and even highlighted across multiple levels of resolution
  - **Including octaves 1, 2 and 3**

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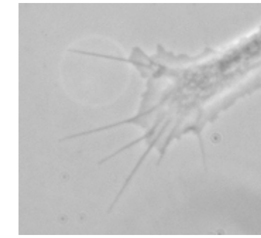
# References

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