### TEAM BLOB

IN CASE YOU Forgot

PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD WATERSHED

#### Sketch i1 Out!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs A Life?

### TEAM BLOB Blob Segmentation

## AUSTIN ADAMS, KC SKUBIC, LEIGHANN VAN DEVENTER, and G.D. YOUNG

Department of Mathematics and Statistics California State University, Long Beach

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Trial and Error

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SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A Life?



### Abstract

Given a set of placental histology slides our goal was to isolate blobs and their corresponding vessels, then compare the results for accuracy.

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Who Needs a Life? Examine different preprocessing applications
 Apply various blob segmentation methods
 Take a hand sketching of isolated blobs and compare methods
 Determine accuracy

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#### Trial and Error

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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

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- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

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  - Determine accuracy

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## Break it Down

### TEAM BLOB

### 1 In Case you Forgot

- Histology Slides
- Preprocessing
- From Zero to Image Processing

### 2 Image Segmentation Methods

- K-means Method
- Chan Vese
- Edge Detection
- Histogram Method
- Watershed
- No One's Perfect

### 3 Hand-sketched Histology Slides

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- Sketch and Scan
- Comparisons

### 4 Who Needs a Life?

The End

### IN CASE YC Forgot

#### HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

- TRIAL AND ERROF K-MEANS METHO CHAN VESE EDGE DETECTION
- HISTOGRAM METH
- WATERSHED

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### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

### CONCLUSION

Who Needs a Life?

### What is a Histology Slide? Original Histology Slide

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In Case you Forgot

HISTOLOGY SLIDES

PREPROCESSING FROM ZERO TO

Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAI COMPARISONS

CONCLUSION

WHO NEEDS A LIFE? A Histology slide the microscopic image of a perpendicular bisection of the placenta. It portrays the maternal and fetal tissues as 2-D cross-sectional blobs.



Figure: Original Image

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### What is a Histology Slide? A Closer Look at The Blob

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#### HISTOLOGY SLIDES

PREPROCESSING FROM ZERO TO

IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD WATERSHED

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAL COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?

### Full SLIDE $\rightarrow$ VILLUS $\rightarrow$ BLOOD VESSELS/ Cell NUCLEI



### Figure: Zoomed In

### Color Me Mine Different Color Channels

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#### HISTOLOGY SLIDES

#### PREPROCESSING

FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOR WATERSHED NO ONE'S PERFECT

#### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

### RGB Color Space

2 Lab Color Space

### 3 HSV Color Space



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### Color me Mine RGB Color Space

### R: red, G: green, B: blue



### Figure: Original Image in RGB

### TEAM BLOB

### FORGOT Histology Slide: Preprocessing

#### PREPROCESSING

FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCA COMPARISONS

CONCLUSION

Who Needs a Life?

### Lab Intensity Corridoring Lab Color Space

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FROM ZERO TO IMAGE PROCESSING

Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCA COMPARISONS

CONCLUSION

WHO NEEDS A LIFE? "L": lightness of color, "a": redness vs. greenness, "b": yellowness vs. blueness



Figure: Lab Corridoring Image

### Color Me Mine HSV Color Space

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#### IN CASE YOU FORGOT Histology Slides Preprocessing

FROM ZERO TO IMAGE PROCESSING

Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

#### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?

### H: Hue, S: Saturation, V: Value



### Figure: Original Image in the Saturated Channel

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### From Zero to Image Processing Reference Algorithm

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TRIAL AND Error

K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO

NO ONE'S PERFECT

#### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life? Quantifying Clinically Significant Features of Placental Histology Images: a Method

By: Morten Andersen , David Belangery, Radina Droumeva, Jenny Lix, Gilbert Moss, Gabriela Palauk August, 2008

 Similar project: Segmentation of Placental "Blobs"
 Uses K-means Segmentation with Mahalanobis Distance Metric

Potential for Comparison

Lesson Learned: Data Set Determines Algorithm

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### From Zero to Image Processing Reference Algorithm

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- 2 Potential for Comparison
  - Lesson Learned: Data Set Determines Algorithm

### Results Using Their Method Our Histology Image

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IN CASE YOU FORGOT HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

ERROR TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCA COMPARISONS

CONCLUSION

Who Needs a Life? "You are absolutely right - lesson number one in image processing - you need to carefully choose and adapt methods for application-specific requirements" -Radina Droumeva



Figure: Resulting Histology Image



#### In Case you Forgot

HISTOLOGY SLIDES

FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

#### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

### Problems with their Method

### Image Resolution

Difficulties Distinguishing: shades of pink/rec

Predetermined Color Markers

Sensitive to Blob Boundaries

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SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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### NO ONE'S PERFECT

### SKETCH IT OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

## Problems with their Method

### Image Resolution

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- Predetermined Color Markers
- 4 Sensitive to Blob Boundaries

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TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

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SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

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### TEAM BLOB

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#### FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

- TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED
- NO ONE'S PERFECT

### SKETCH IT OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

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- 4 Sensitive to Blob Boundaries

### **Results Using Their Method** Our Histology Image

### TEAM BLOB

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Figure: Resulting Histology Image Figure: Resulting Histology Image

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#### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

### Methods We Tried

K-means

- Euclidean
- Mahalanobis

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Chan Vese

Edge Detection

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FROM ZERO TO IMAGE PROCESSING

Trial and Error

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### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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FROM ZERO TO IMAGE PROCESSING

Trial and Error

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SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

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NO ONE'S PERFECT

### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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- 3 Edge Detection
- 4 Watershed



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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING

FROM ZERO TO IMAGE PROCESSING

Frial and Error

#### TRIAL AND ERROR

K-means Metho Chan Vese

EDGE DETECTION

WATERSHED

NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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- 3 Edge Detection
- 4 Watershed
- 5 Histogram

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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

Trial and Error

K-MEANS METHOD

CHAN VESE

EDGE DETECTION

HISTOGRAM METHO

WATERSHED

### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

### Verbal Break Down

Euclidean Distance - Lab Space Matlab's built in K-Means Algorithm

4 vs. 5 Cluster Centers

4: Lumps light pink with light purple, some pink with rec
 5: Separates Red, Pink, Light Purple, Blue, and White effectively

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Blobs are the inverse of the White Segmentation
Result: Slow but reasonably effective "Discrete Method

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EDGE DETECTION

HISTOGRAM METHO

WATERSHED

NO ONE'S PERFECT

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SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

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K-MEANS METHOD

CHAN VESE

EDGE DETECTION

HISTOGRAM METHO

WATERSHED

### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

IMAGE PROCESSING

Trial ane Error

TRIAL AND ERROR

K-MEANS METHOD

CHAN VESE

EDGE DETECTION

HISTOGRAM METHO

WATERSHED

### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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### In Case you Forgot

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#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



### Figure: Histology Slide 1

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TRIAL AND ERROR TRIAL AND ERROI K-MEANS METHO CHAN VESE EDGE DETECTION HISTOGRAM METT WATERSHED

SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



### Figure: Total Segmentation 1

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### K-Means Euclidean Proves Promising

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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

#### SKETCH I OUT!

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CONCLUSION

Who Needs a Life?



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## K-means Killer K-means Euclidean Method

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SKETCH II

SKETCH IT OUT! SKETCH AND SCAL COMPARISONS

CONCLUSION

Who Needs a Life?



## K-means Killer K-means Euclidean Method Results

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERROR K-MEANS METHON CHAN VESE EDGE DETECTION HISTOGRAM METH WATERSHED

#### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



## Figure: Total Segmentation 2

## K-means Killer K-means Euclidean Method

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

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#### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

WHO NEEDS A Life?



## K-means Killer K-means Euclidean Method Results

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METH WATERSHED

#### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?



### Figure: Total Segmentation 3

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## K-means Killer Mahalanobis Distance in RGB Space

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#### In Case you Forgot

- HISTOLOGY SLIDES PREPROCESSING
- FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

- TRIAL AND ERROR
- K-MEANS METHOD
- CHAN VESE
- EDGE DETECTION
- HISTOGRAM METHO
- WATERSHED

#### SKETCH IT OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

## Verbal Break Down

- **1** Weights distance to an absolute color marker
  - Set by variance in each channel of RGB color space
  - Result: Using fixed color markers across variant variance structures creates segmentation distortions

## Further Work Ideas

- Use the Covariance Matrix of a single representative image
- Use the Covariance of the entire population of images
  Report the "Volatility of Volatility" in the image set as indicator of likely success

## K-means Killer Mahalanobis Distance in RGB Space

#### TEAM BLOB

#### In Case you Forgot

- HISTOLOGY SLIDES PREPROCESSING
- FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

- TRIAL AND ERROR
- K-MEANS METHOD
- CHAN VESE
- EDGE DETECTION
- HISTOGRAM METHOI
- WATERSHED
- NO ONE'S PERFECT

#### SKETCH II OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

## Verbal Break Down

- U Weights distance to an absolute color marker
  - Set by variance in each channel of RGB color space
  - Result: Using fixed color markers across variant variance structures creates segmentation distortions
- 2 Further Work Ideas
  - Use the Covariance Matrix of a single representative image
  - Use the Covariance of the entire population of images
  - Report the "Volatility of Volatility" in the image set as indicator of likely success

## K-means Killer Original Image

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERROI K-MEANS METHO CHAN VESE EDGE DETECTION HISTOGRAM METH WATERSHED

NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



## K-means Killer Original Image

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR Trial and Erro K-means Metho Chan Vese Edge Detection Histogram Met Waterscherd

SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAT COMPARISONS

CONCLUSION

Who Needs a Life?



## K-means Killer Original Image

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR Trial and Erro K-means Metho Chan Vese Edge Detection Histogram Met

WATERSHED

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?



## K-Means, Mahalanobis, RGB Space Histology Slide Calibrations

#### TEAM BLOB

#### IN CASE YOU FORGOT

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### TRIAL AND ERROR TRIAL AND ERRO

K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOE WATERSHED NO ONE'S PERFECT

#### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?





### Figure: Calibration 1

Figure: Calibration 2

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## K-Means, Mahalanobis, RGB Space Histology Slide Calibrations

#### TEAM BLOB

#### IN CASE YOU FORGOT

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOE WATERSHED NO ONE'S PERFECT

#### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?



## Figure: Calibration 1

Figure: Calibration 2

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## K-Means, Mahalanobis, RGB Space Histology Slide Calibrations

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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERROR **K-MEANS METHOD** CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

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SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?





### Figure: Calibration 1

Figure: Calibration 2

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#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR

- K-MEANS METHOD
- CHAN VESE
- EDGE DETECTION
- HISTOGRAM METHO
- WATERSHED
- NO ONE'S PERFECT

#### SKETCH IT OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

## Verbal Break Down

## $\blacksquare \ \mathsf{RGB} \to \mathsf{Lab}$

- Mahalanobis calculation in the L, a, and b planes.
- Distance in Light Intensity Value weighted in the Mahalanobis calculation
- Result: Removes distortion from the Mahalanobis calculation

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR

- K-MEANS METHOD
- CHAN VESE
- EDGE DETECTION
- HISTOGRAM METHO
- WATERSHED
- NO ONE'S PERFECT

#### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

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#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

Trial and Error

TRIAL AND ERROR

CHAN VESE

EDGE DETECTION

HISTOGRAM METHO

WATERSHED

#### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

## Verbal Break Down

 $\blacksquare \ RGB \rightarrow Lab$ 

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- 3 Distance in Light Intensity Value weighted in the Mahalanobis calculation
  - Result: Removes distortion from the Mahalanobis calculation

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#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

Trial and Error

TRIAL AND ERROR

K-MEANS METHOD

EDGE DETECTIO

HISTOGRAM METHO

WATERSHED

NO ONE'S PERFECT

#### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?

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#### TEAM BLOB

#### IN CASE YOU FORGOT

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOI WATERSHED NO ONE'S PERFECT

#### SKETCH IT OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?



## Figure: Segmented Vessels



### Figure: Total Segmentation

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#### IN CASE YOU FORGOT

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### TRIAL AND ERROR Trial and Error K-MEANS METHOD Chan Vese Edge Detection Histogram Metho Watershed

#### SKETCH IT OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?



### Figure: Segmented Vessels



### Figure: Total Segmentation

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOD

#### CHAN VESE

EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

## Mumford-Shah functional outline provided by: Zoltan Kato

## Mumford-Shah functional

Let *f* be differentiable on ∪ *R<sub>i</sub>* and allowed to be discontinuous across Γ.
 *E*(*f*, Γ) = μ<sup>2</sup> ∫∫<sub>R</sub> (*f* − *g*)<sup>2</sup> *dxdy* + ∫∫<sub>R</sub> ||∇*f*||<sup>2</sup> *dxdy* + *v*|Γ|
 The smaller *E*, the better (*f*, Γ) segments *g* Dropping any term would cause *infE* = 0

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

Trial and Error

TRIAL AND ERROR K-MEANS METHOR

CHAN VESE

EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE? Mumford-Shah functional outline provided by: Zoltan Kato

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 The smaller *E*, the better (*f*, Γ) segments *g f* approximates *g f* (hence *g*) does not vary much on *R<sub>i</sub>*'s
 The boundary Γ be as short as possible

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

Trial and Error

TRIAL AND ERROR K-MEANS METHOD

CHAN VESE

EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE? Mumford-Shah functional outline provided by: Zoltan Kato

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

TRIAL AND Error

TRIAL AND ERROR K-MEANS METHOR

CHAN VESE

EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE? Mumford-Shah functional outline provided by: Zoltan Kato

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 The smaller *E*, the better (*f*, Γ) segments *g f* approximates *g*

2 f (hence g) does not vary much on  $R_i$ 's

3 The boundary I be as short as possible

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO

Trial and Error

TRIAL AND ERROR K-MEANS METHOE

CHAN VESE

EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?

## Mumford-Shah functional outline provided by: Zoltan Kato

## Mumford-Shah functional

- Let *f* be differentiable on  $\bigcup R_i$  and allowed to be discontinuous across  $\Gamma$ .  $E(f,\Gamma) = \mu^2 \iint_R (f-g)^2 dx dy + \iint_R \iint_\Gamma ||\nabla f||^2 dx dy + v|\Gamma|$
- The smaller *E*, the better  $(f, \Gamma)$  segments *g* 
  - f approximates g
  - 2 f (hence g) does not vary much on  $R_i$ 's
  - **3** The boundary Γ be as short as possible

#### TEAM BLOB

#### In Case you Forgot

- HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO
- TRIAL AND Error
- TRIAL AND ERROR K-MEANS METHOR
- CHAN VESE
- EDGE DETECTION HISTOGRAM METHOD WATERSHED

#### SKETCH I OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

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- The smaller *E*, the better  $(f, \Gamma)$  segments *g* 
  - f approximates g
  - 2 f (hence g) does not vary much on  $R_i$ 's
  - 3 The boundary Γ be as short as possible
  - Dropping any term would cause infE = 0

## Chan Vese Method Cartoon Image Example

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#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

Trial and Error

TRIAL AND ERROR K-MEANS METHOD

CHAN VESE

EDGE DETECTION HISTOGRAM METHOE WATERSHED NO ONE'S REFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?

## Cartoon Image Example provided by: Zoltan Kato



## (a) Example Image 1



(c) Example Image 2



(b) Example Image 1 After



(d) Example Image 2 After



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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERRI

K-MEANS METHOD

CHAN VESE

EDGE DETECTION HISTOGRAM METHOE WATERSHED NO ONE'S PERFECT

#### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?







Figure: Using Histology Slide 1

## Chan Vese is a Work in Progress Still Needs Work

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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERR

K-MEANS METHOR

CHAN VESE

EDGE DETECTION HISTOGRAM METHOE WATERSHED NO ONE'S REFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?



Figure: Using Histology Slide 1 ( 2 ) ( 2 )

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150 200

## Edge Detection Inspection Edge Detection Method



## Find Binary Image

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# Edge Detection Inspection

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SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

## Edge Detection Inspection Edge Detection Method



## Verbal Break Down

- Find Binary Image
- 2 Use Canny Edge Detection

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3 Merge Disjoint Regions

## Edge Detection Inspection

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

Trial and Error

TRIAL AND ERROR K-MEANS METHOR

CHAN VESE

EDGE DETECTION

WATERSHED

NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?



## Figure: Histology Slide 1

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## Edge Detection Inspection

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

#### Trial and Error

TRIAL AND ERROR K-MEANS METHOE CHAN VESE

#### EDGE DETECTION

HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



Figure: Black and White of Original 1

## Edge Detection Method Results Blobs Only

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### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

TRIAL AND ERROR TRIAL AND ERF

CHAN VESE

EDGE DETECTION

HISTOGRAM METHOD WATERSHED

#### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



## Figure: Segmented Blobs of Original 1

## Edge Detection Method Results Blobs and Vessels

#### TEAM BLOB

#### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

FRIAL AND ERROR Trial and Error K-means Methor Chan Vese Edge Detection

HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

#### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAT COMPARISONS

CONCLUSION

Who Needs a Life?



Figure: Segmented Blobs and Vessels of Original 1

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## Histology and Histogram go Hand-in-Hand Histology Method



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CONCLUSION

Who Needs a Life?

## Histology and Histogram go Hand-in-Hand Histology Method



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CONCLUSION

WHO NEEDS A LIFE?
# Histology and Histogram go Hand-in-Hand Histology Method



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# Histogram Method Results Blobs Only

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?



# Figure: Original



## Figure: Blobs Segmented 200

# Histogram Method Results Blobs Only

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD

WATERSHED NO ONE'S PERFECT

### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Blobs Segmented Take 2

# Histogram Method Results Blobs and Vessels

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### TRIAL AND Error

- K-MEANS METHOE CHAN VESE
- EDGE DETECTION

### HISTOGRAM METHOD WATERSHED

NO ONE'S PERFECT

### SKETCH I OUT!

- SKETCH IT OUT! SKETCH AND SCAP COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?

# Color blobs indicate Villi and white indicates the blood vessels.



Figure: Blobs and Vessels Segmented



### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOP WATERSHED NO ONE'S PERFECT

### Sketch it Out!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

# Verbal Break Down

# Find Binary Image

Find Distance Transform of Image

Run Watershed on Distance Transform



### IN CASE YOU Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

### SKETCH IT OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?

# Verbal Break Down

# Find Binary Image

2 Find Distance Transform of Image

Run Watershed on Distance Transform



### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

### Sketch it Out!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?

# Verbal Break Down

- Find Binary Image
- 2 Find Distance Transform of Image
- 3 Run Watershed on Distance Transform

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAL COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Histology Slide 1

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOR WATERSHED NO ONE'S PERFECT

### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAT COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Black and White of Original 1

# Watershed Method Results Blobs Only

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Segmented Blobs of Original 1

# Watershed Method Results Blobs and Vessels

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

### SKETCH I OUT!

SKETCH IT OUT! SKETCH AND SCAP COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Segmented Blobs and Vessels of Original 1

# Sketch and Scan Hand-Tracings of Original Images

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD WATERSHED NO ONE'S PERFECT

### Sketch it Out!

SKETCH IT OUT: SKETCH AND SCAL COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Histology Slide 1

# Sketch and Scan Hand-Tracings of Histology Slide 1

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial ani Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED NO ONE'S PERFECT

### SKETCH II OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?



Figure: Outlined Blobs



# Figure: Outlined Vessels 500

# Sketch and Scan Hand-Tracings of Original Images

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOR WATERSHED NO ONE'S PERFECT

### Sketch it Out!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Histology Slide 2

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# Sketch and Scan Hand-Tracings of Histology Slide 2

### TEAM BLOB

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HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial ani Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOR WATERSHED NO ONE'S PERFECT

### SKETCH I1 OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

CONCLUSION

WHO NEEDS A LIFE?



Figure: Outlined Blobs



Figure: Outlined Vessels

# Sketch and Scan Hand-Tracings of Original Images

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOR WATERSHED NO ONE'S PERFECT

### Sketch i1 Out!

SKETCH IT OUT! SKETCH AND SCAT COMPARISONS

CONCLUSION

Who Needs a Life?



# Figure: Histology Slide 3

# Sketch and Scan Hand-Tracings of Histology Slide 3

### TEAM BLOB

### In Case you Forgot

HISTOLOGY SLIDES PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial ani Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHO WATERSHED

### SKETCH II OUT!

- SKETCH IT OUT! SKETCH AND SCAN COMPARISONS
- CONCLUSION
- WHO NEEDS A LIFE?



Figure: Outlined Blobs



# Figure: Outlined Vessels

# Judging a Book by its Cover Comparing Blob Area



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# Judging a Book by its Cover Comparing Vessel Area



- SKETCH IT OUT! SKETCH AND SCAL
- CONCLUSION
- WHO NEEDS A LIFE?

# TEAM BLOB

SKETCH AND SCAP Comparisons

### CONCLUSION

WHO NEEDS A LIFE? Further Examination of Chan Vese Metho
Combinations of Existing Methods
A Deeper Analysis of Our Data

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### TEAM BLOB

### IN CASE YOU FORGOT

PREPROCESSING FROM ZERO TO IMAGE PROCESSING

### Trial and Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD WATERSHED

### SKETCH II OUT!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

### CONCLUSION

WHO NEEDS A LIFE?

# Further Examination of Chan Vese Method

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Combinations of Existing Methods

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### CONCLUSION

WHO NEEDS A LIFE?

# Further Examination of Chan Vese Method Combinations of Existing Methods

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A Deeper Analysis of Our Data

### TEAM BLOB

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### Sketch 11 Out!

SKETCH IT OUT! SKETCH AND SCAN COMPARISONS

### CONCLUSION

WHO NEEDS A LIFE?

# Further Examination of Chan Vese Method

- 2 Combinations of Existing Methods
- 3 A Deeper Analysis of Our Data

# Who Needs a Life?

### TEAM BLOB

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PREPROCESSING FROM ZERO TO

### TRIAL AND Error

TRIAL AND ERROR K-MEANS METHOD CHAN VESE EDGE DETECTION HISTOGRAM METHOD WATERSHED

### SKETCH I' OUT!

SKETCH IT OUT! SKETCH AND SCAT COMPARISONS

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# Questions?



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COMPARISONS CONCLUSION