

Automatic Glomerulus Extraction in Whole Slide Images Towards Computer Aided Diagnosis

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Norma Kenyon², Rachana Patil³, Andre Balla³ and Amelia
Bartholomew³

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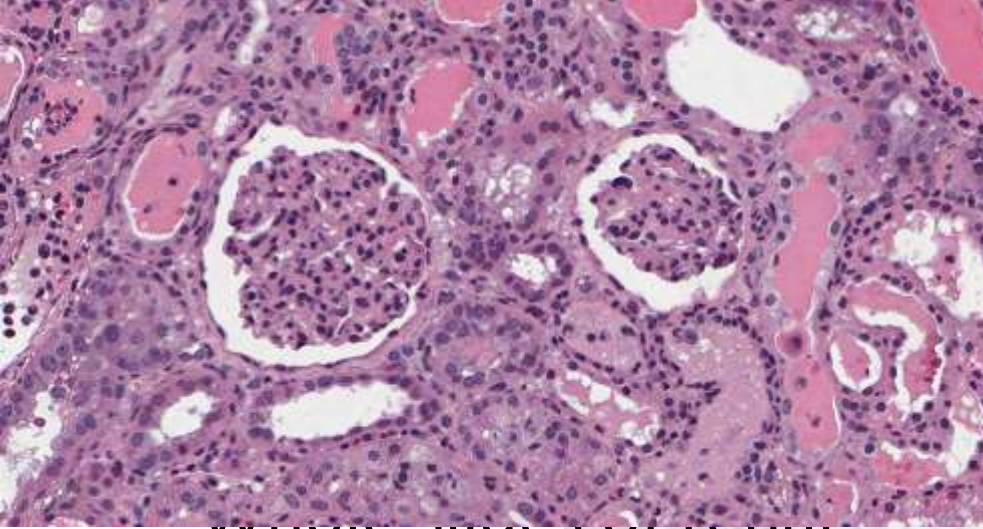
² Diabetes Research Institute, University of Miami

³ Department of Surgery and Bioengineering University of Illinois at Chicago



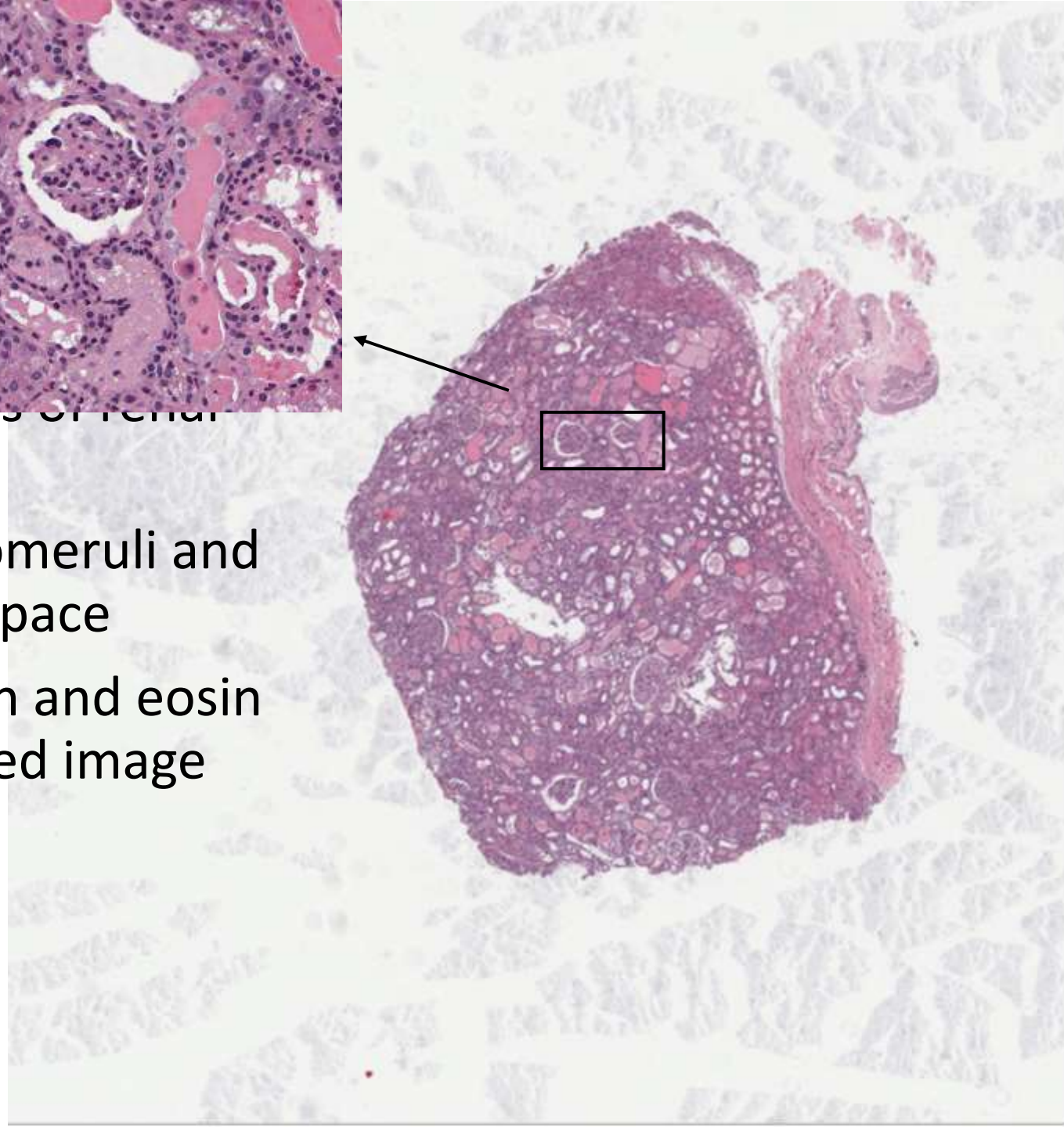
Outline

- ✓ Background
 - Automatic Glomerulus Extraction
 - Computer Aided Diagnosis
 - BrownDog & conclusions



Whole slides of renal
tissues

- Tubules, glomeruli and interstitial space
- Hematoxylin and eosin (H&E) stained image
- Biomarkers

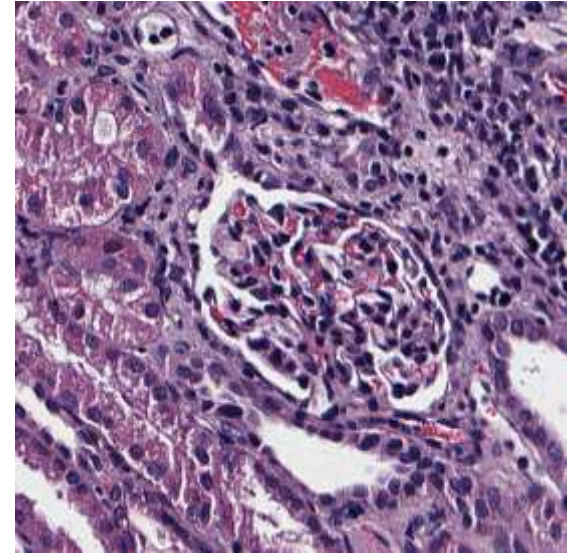
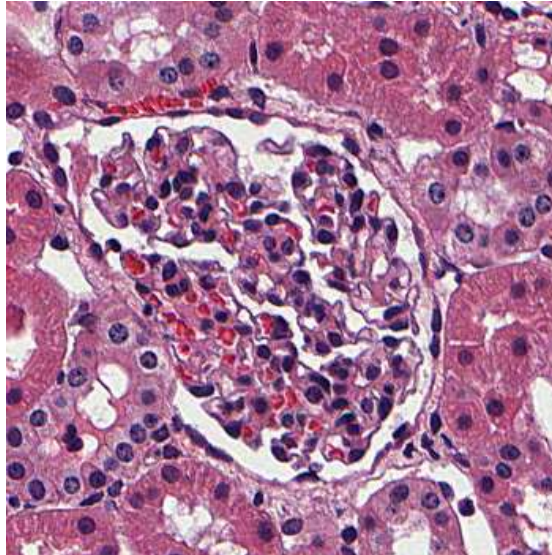
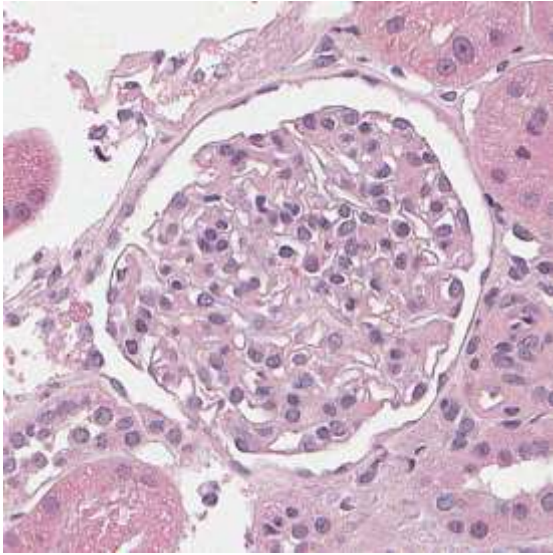


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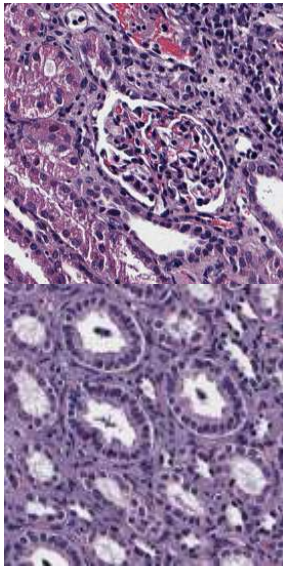
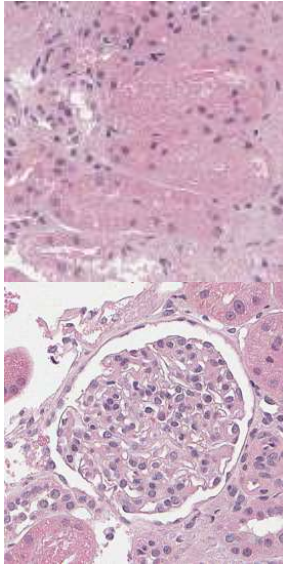
Glomerulus

- Bowman's capsule/ space
- Challenges: different color, different shape & size of glomeruli, incomplete and blur Bowman's space

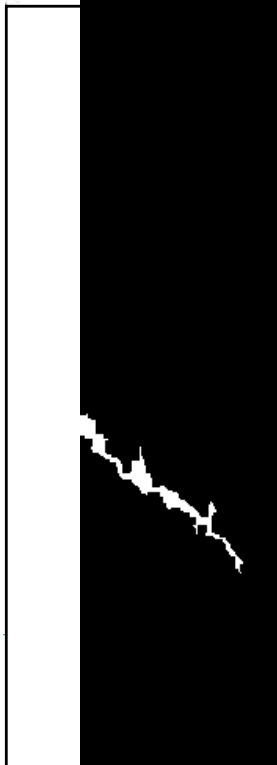
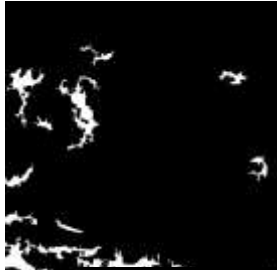


Automatic glomerulus extraction

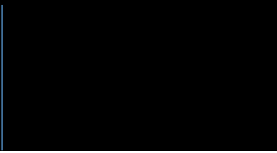
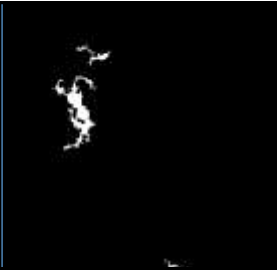
Original Image



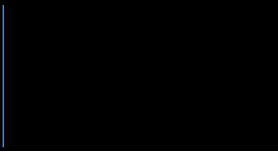
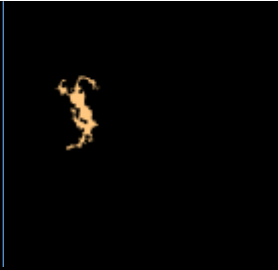
*Object
Generation*



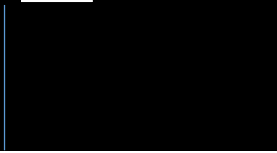
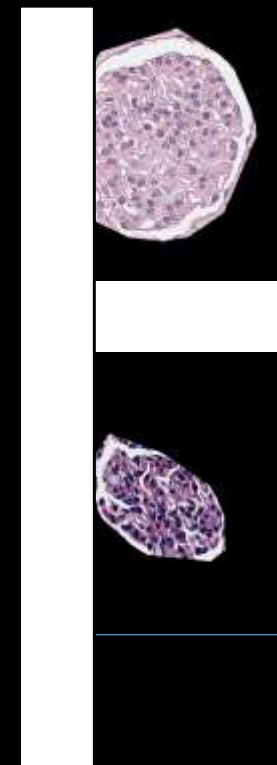
*Morphological
Classification*



*Perceptual
Grouping*



*Glomerulus
Segmentation*



Evaluation

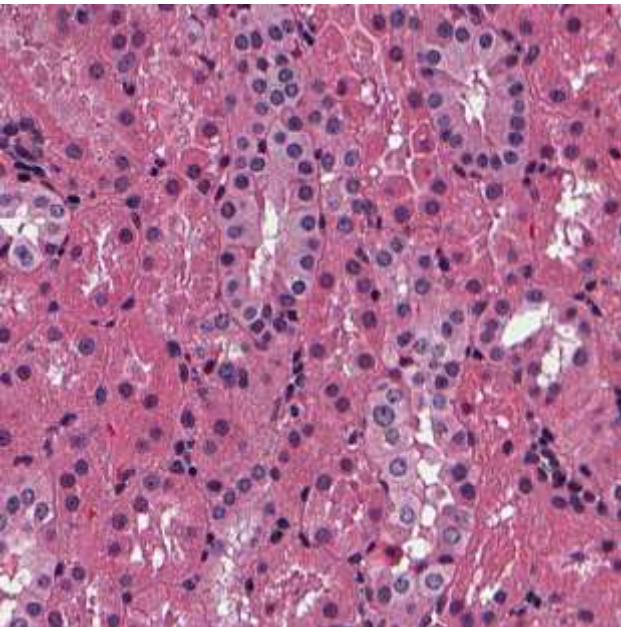
TABLE I: overall performance of glomerulus extraction

Parameters	CN8454	CN8452	CN8450	CN8383	CN8376
# Real Glomeruli	8	6	37	80	9
# Glomeruli Detected	5	4	23	73	5
Completeness(%)	80.6	100	91.6	96.9	73.0
# False Glomeruli	0	0	1	15	13
Time(s)	9.3	3.5	10.2	65.6	12.3

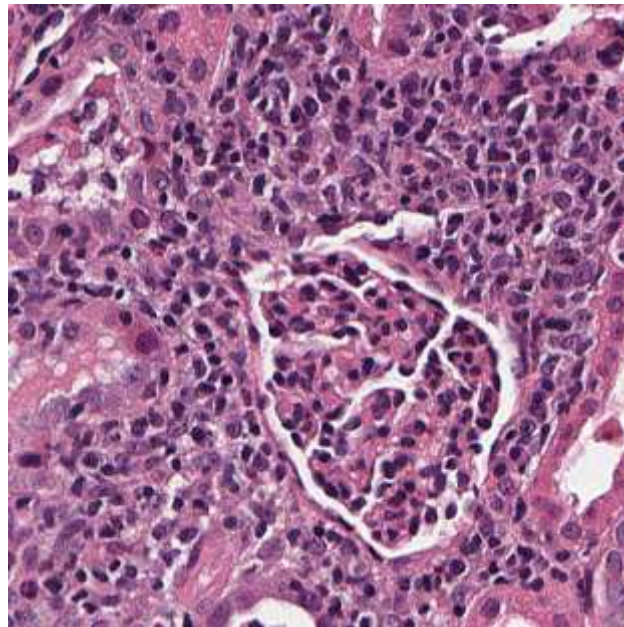
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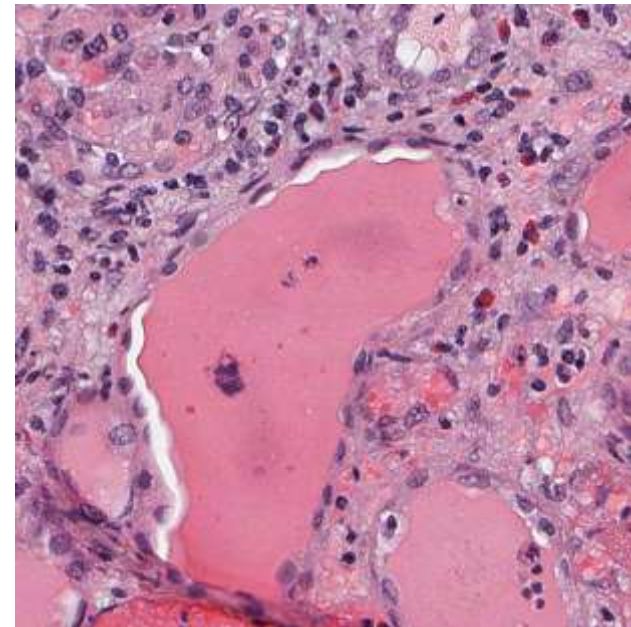
Post-transplant renal biopsies



(a) Normal



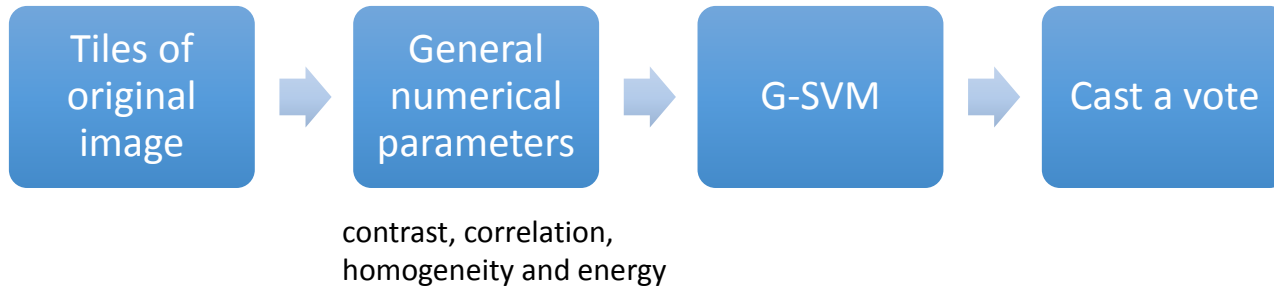
(b) Interstitial inflammation



(c) Tubular cast

Computer Aided Diagnosis

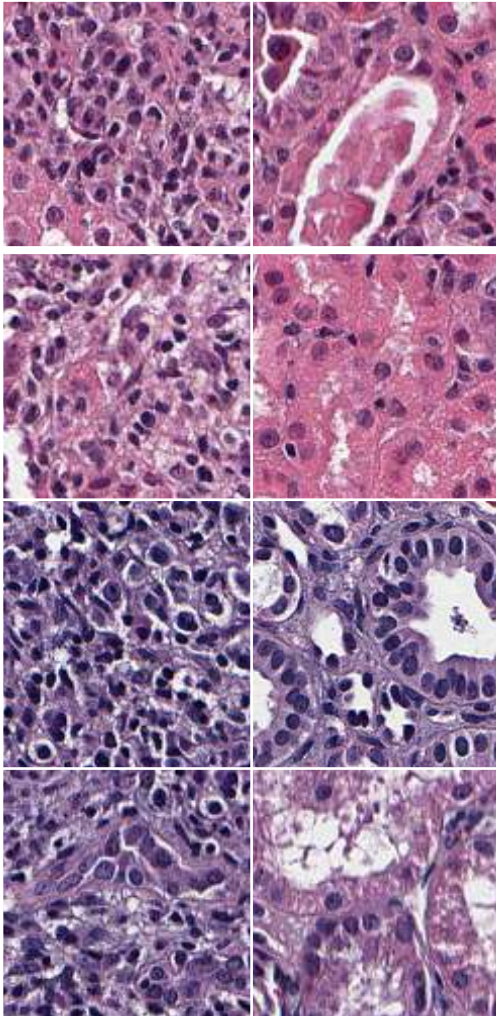
- *Pre-Screening*



- *Search the Biomarkers of Diagnosis*



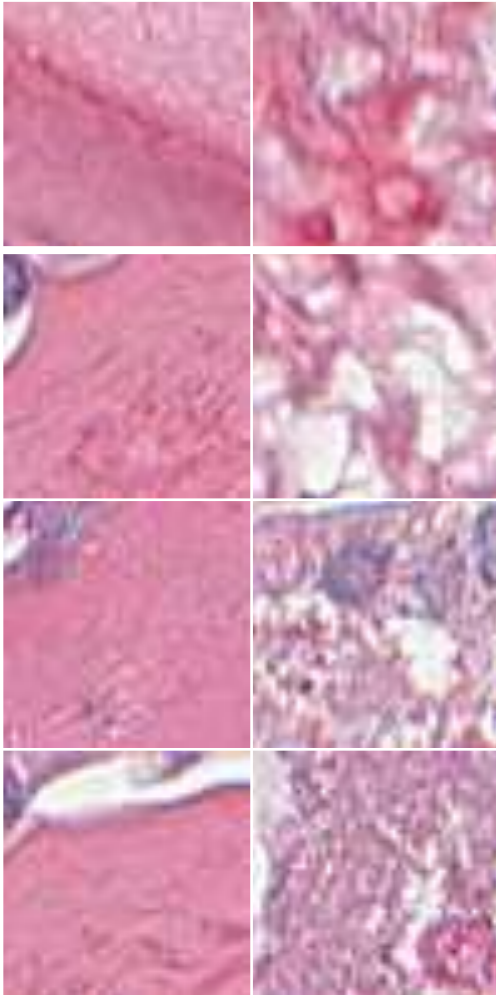
Experiment & Evaluation



- 200 x 200 pixel
- Cell number (the number of pixels with weak color intensity with maximum length ranging from 3 to 30 pixel)
- The percentage of white area (light color area above 100 pixels)
- Correlation, cluster prominence, maximum probability and inverse difference moment normalized
- Precision as 98% for 6 samples.

Fig. TP and FP of Pre-screening

Experiment & Evaluation



- 50 x 50 pixel
- **Smooth degree** (median of local range of color among 7*7 neighborhood in red and blue channel)
- **Color saturation** (median of hue and saturation channels)
- Information measure of difference variance, difference entropy and sum entropy

- Precision as 98% for 4 samples

Fig. TP and FP of Pre-screening

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BrownDog Service

Clowder Spaces Datasets Collections Users Search

computer-aid diagnosis


Created by Yan Zhao All Rights Reserved Yan Zhao
Created on May 26, 2016

This is the demonstration for computer-aid diagnosis & automatic glomerulus detection in CR project.

The centroids of glomerulus, as well as the condition of tubular casts and interstitial inflammation, are listed in metadata.

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CN8452_POD6_11-20-13.tiff
image/tiff
May 27, 2016
9.6 MB
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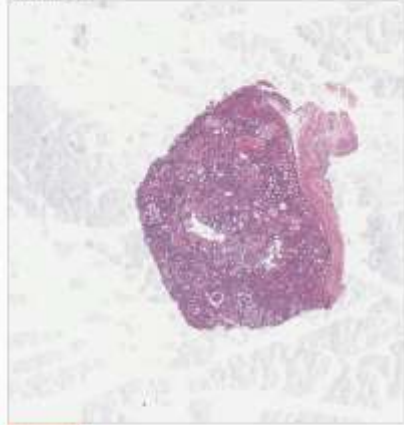
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CN8452_POD6_11-20-13.tiff

in computer-aid diagnosis

Add a description



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Metadata

Extracted by <http://howler.zoo.illinois.edu/extractor/prepare.html> on May 27, 2016

- contains
 - Tubular Casts: 100
 - Glomerulus:
 - 3228 71 3228 71
 - 3228 71 3484 33
 - 3404 58 3773 13
 - 3163 11 3753 13

Tags

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Type: image/tiff
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MSC Home Browse Subjects Attributes Initialisation Attribute Selection Data Mining

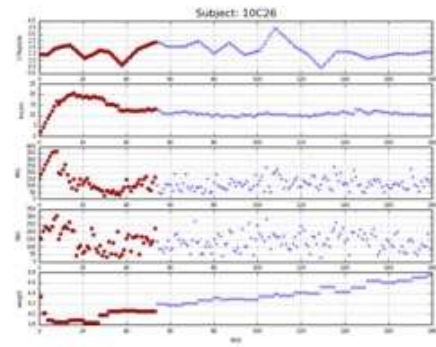
Data Mining

Launch data mining job on data. Select the method, subjects and input/output attributes. Then click submit.

Method	Attributes	Subjects																																																
<ul style="list-style-type: none"> <input type="checkbox"/> Decision Tree - J48 Class for generating a pruned or unpruned D2. <input type="checkbox"/> Hidden Markov Model A statistical model with hidden states. <input type="checkbox"/> SVM - SMO Implements John Platt's sequential minimal optimization algorithm for training a support vector classifier. <p>Number of States: 2 Number of POI: 180</p>	<table border="1"> <tr><td><input type="checkbox"/></td><td>Abs Count C00 & 25-127</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C00 & 68</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C00 & Class 0</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C00 9</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C00 & 25</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C00 & 86</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C00 & Class 0</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C04 Central Memory C006 & 29-3</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C04 Effector Memory C006 & 29-3</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C046 beta0</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C046 - 117</td></tr> <tr><td><input type="checkbox"/></td><td>Abs Count C046 - 117 31 - 106</td></tr> </table>	<input type="checkbox"/>	Abs Count C00 & 25-127	<input type="checkbox"/>	Abs Count C00 & 68	<input type="checkbox"/>	Abs Count C00 & Class 0	<input type="checkbox"/>	Abs Count C00 9	<input type="checkbox"/>	Abs Count C00 & 25	<input type="checkbox"/>	Abs Count C00 & 86	<input type="checkbox"/>	Abs Count C00 & Class 0	<input type="checkbox"/>	Abs Count C04 Central Memory C006 & 29-3	<input type="checkbox"/>	Abs Count C04 Effector Memory C006 & 29-3	<input type="checkbox"/>	Abs Count C046 beta0	<input type="checkbox"/>	Abs Count C046 - 117	<input type="checkbox"/>	Abs Count C046 - 117 31 - 106	<p>Select All</p> <table border="1"> <tr><td><input type="checkbox"/></td><td>10C26</td></tr> <tr><td><input type="checkbox"/></td><td>160219</td></tr> <tr><td><input type="checkbox"/></td><td>16028</td></tr> <tr><td><input type="checkbox"/></td><td>11C27</td></tr> <tr><td><input type="checkbox"/></td><td>11C28</td></tr> <tr><td><input type="checkbox"/></td><td>12C13</td></tr> <tr><td><input type="checkbox"/></td><td>12C26</td></tr> <tr><td><input type="checkbox"/></td><td>12C31</td></tr> <tr><td><input type="checkbox"/></td><td>12C39</td></tr> <tr><td><input type="checkbox"/></td><td>12C79</td></tr> <tr><td><input type="checkbox"/></td><td>12C6</td></tr> <tr><td><input type="checkbox"/></td><td>12C26</td></tr> </table>	<input type="checkbox"/>	10C26	<input type="checkbox"/>	160219	<input type="checkbox"/>	16028	<input type="checkbox"/>	11C27	<input type="checkbox"/>	11C28	<input type="checkbox"/>	12C13	<input type="checkbox"/>	12C26	<input type="checkbox"/>	12C31	<input type="checkbox"/>	12C39	<input type="checkbox"/>	12C79	<input type="checkbox"/>	12C6	<input type="checkbox"/>	12C26
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Conclusions

- Currently, renal biopsies are analyzed manually; the availability of fully automatic diagnosis framework is of immense benefit in leveraging the expertise and preventing graft loss.
- Computer Aided Diagnosis of Interstitial inflammation and tubular cast achieves precision as 90% in average. First work in this field.
- For glomerulus extraction, 110 out of 140 glomeruli from five WSIs are correctly extracted with average completeness over 90%.
- 46.1s for an 112MB-pixel-foreground image, make it possible for routine CAD process.
- The entire framework is integrated in Clowder as web service and demonstrated in CRI dataset. Open source code is available.