Gradient Weighted Co-Hog for Analysis of Caudal Vein Structural Changes in Toxin Exposed Zebrafish embryo

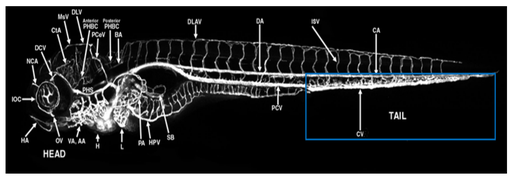
C. Hans, C. W. McCollum, M. B. Bondesson, S.K. Shah, F.A. Merchant

University of Houston

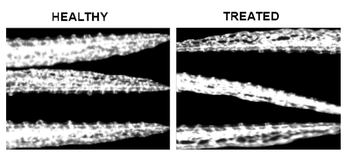
Quantitative Imaging Laboratory

Problem

- The vascular system is a vital component of all vertebrate animals.
- Several toxins could act as vascular disrupting compounds by targeting blood vessel development.
- A wide range of diseases are associated with the adverse effects of exposure to toxic elements.
- Thus, there is a critical need to identify the vascular disruptors out of thousands of industrial chemicals.
- Zebrafish model has been increasingly utilized for studying vascular structure.
- Why Zebrafish:
  · Small size · Transparency · Fast development · High fertility · External development



- Quantification of the Caudal Vein (CV) region of a zebrafish embryo to understand the effects of toxins on vascular development.
- Fine meshwork of the CV is observed in healthy embryos.
- Treated embryos exhibit the formation of loops or aberration in the CV.

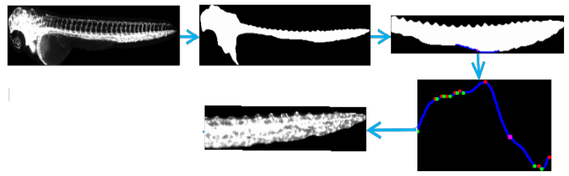


- **Morphological changes due to toxin exposure is detected based on the proposed gradient weighted co-occurrence histogram of oriented gradients (gCo-HOG).**

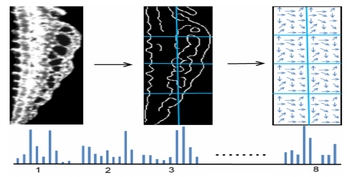
Method

Procedure consist of CV Segmentation followed by CV Shape quantification using Histogram of Gradient (HOG) [1], Co-occurrence histograms (Co-HOG) [2], and the proposed gCo-HOG.

- **Segmentation** procedure consists of edge tracing and curvature analysis.

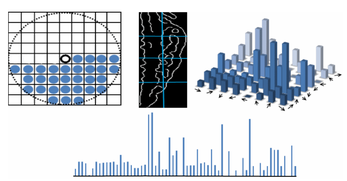


- **HOG** an object shape can be deduced from the distribution of intensity gradient orientations. We propose to use HOG on edge contours.



- **Co-HOG**, is an extension of HOG that captures gradient orientation of neighboring pixel pairs. Co-occurrence matrix $C_{x,y}$ for an image I at a specific offset (x, y) is defined as:

$$C_{x,y}(i,j) = \sum_p \sum_q \begin{cases} 1, & \text{if } I(p,q) = i, I(p+x, q+y) = j \\ 0, & otherwise \end{cases}$$



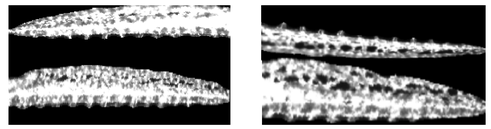
- Limitation of Co-HOG is that it ignores gradient information. To address this limitation, we investigate the inclusion of gradient strength in the generation of the histogram called **gCO-HOG**.

$$C_{x,y} = C_{x,y} + \|g_1 + g_2\|$$

where g_1 and g_2 is the gradient magnitude at location (p, q), $(p + x, q + y)$ respectively.

Results

- Transgenic zebrafish Tg(kdrl:GFP) embryos are exposed to toxins with varying dosage, from 3 hours post fertilization (hpf) to 3 days post fertilization (dpf) and assessed for vascular abnormalities in CV.
- Images are acquired with an Olympus IX-51 fluorescent microscope using a 4X objective and GFP filter.



- Dataset consists of 176 images distinct CV regions, 88 images in the dataset do not show any abnormalities, while the remaining 88 images show structural changes to the CV due to toxicity effects.
- The overall dataset is randomly partitioned into 10 groups, 9 of which are used for training a linear SVM classifier and the remaining group is used for testing. 10-fold cross-validation is used to calculate the accuracy.
- We compared gCo-HoG with Co-HOG and HOG for 360 degree orientation. Experimental results in table show that our proposed descriptor outperforms the other two and has an accuracy of 93.87%.

gCo-HOG	Co-HOG	HOG
93.87	92.08	89.65

- The result shows that our method performs better than Co-HOG and HOG for detection of CV abnormalities.

Conclusion

- To study the mechanism of vascular disruption, we quantified the changes in shape of CV for treated zebrafish embryo against the untreated zebrafish embryo.
- We show that gCo-HOG, can recognize changes in shape of CV region due to exposure to toxins.
- Roughly 80,000 industrial chemicals are registered on the US market, and very few of them have been screened for disrupting properties.
- Thus, development of high throughput screening models that can recognize impacts of toxicity can prove to be very vital.

References

[1] Navneet Dalal and Bill Triggs, *Histograms of oriented gradients for human detection*, CVPR 2005.

[2] Toshikazu Wada, Fay Huang, and Stephen Lin, *Co-occurrence Histograms of Oriented Gradients for Pedestrian Detection*,Advances in Image and Video Technology vol. 5414, 2009.