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Do Computers Dream of Electric Glomeruli?

John D. Bukowy, M.S., Alex Dayton, Ph.D., Dustin Cloutier, Julian H. Lombard, Ph.D., Leah C. Solberg Woods, Ph.D., Daniel A. Beard, Ph.D., and Allen W. Cowley Jr, Ph.D.

By training a convolutional neural network on over 20 000 histological images of rat glomeruli, a computer can be taught to recognize them. After training the network using images with positive examples of glomeruli and negative examples of renal fields with no glomeruli present, new images of renal histology can be passed through the network to determine whether they contain glomeruli. Passing the image forward through the network predicts what objects may be present within the image. Passing images in reverse can be used to ascertain what features the network has been trained to find. With successive reverse passes, features that the network associates with given objects can be imparted onto an image. This previously described image generation method is referred to as DeepDream and can be used to visualize features that a trained network uses to make decisions.

The image presented here shows the result from successive reverse passes using a starting image of random pixels. On each reverse pass, the output of the network slightly alters the starting image to accentuate features it associates with images containing either glomeruli or “background” renal tissue. After enough iterations, the image passed through parts of the network associated with glomeruli (left) shows strong resemblance to glomerular capillary tufts. The image altered using features not associated with glomeruli, shows a strong resemblance to renal tubules (right). These curious DeepDream images are a result of a trained machine learning tool which could ultimately be used to enable automated datamining of renal histological images.

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Correspondence: Phone: 414-955-8277, Fax: 414-955-6546, Address: Medical College of Wisconsin, ATTN: Physiology, Dr. Allen W. Cowley, Jr., 8701 Watertown Plank Rd., Milwaukee, WI 53226, cowley@mcw.edu.

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Figure.

DeepDream visualization of features associated with glomeruli (left) and “Background” renal tissue (right). These images are generated using a convolutional neural network trained to identify glomeruli in bright-field histology. These images provide a representation of features a computer “looks for” when classifying renal histology.