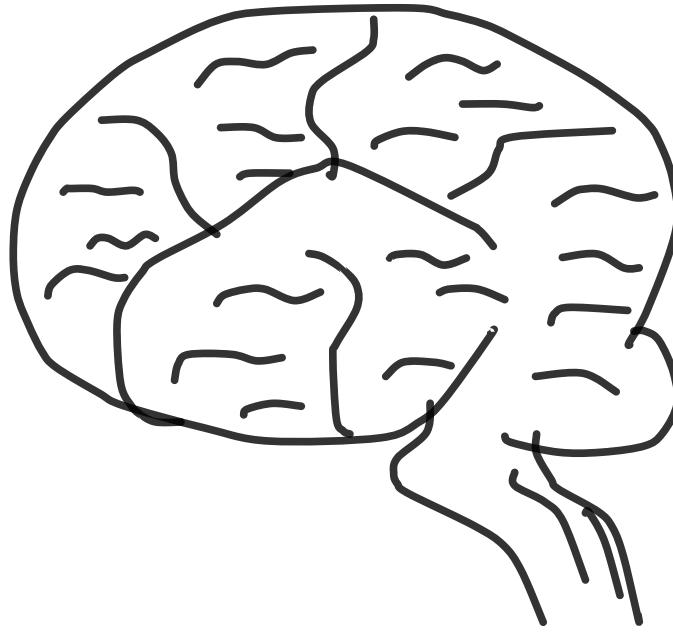
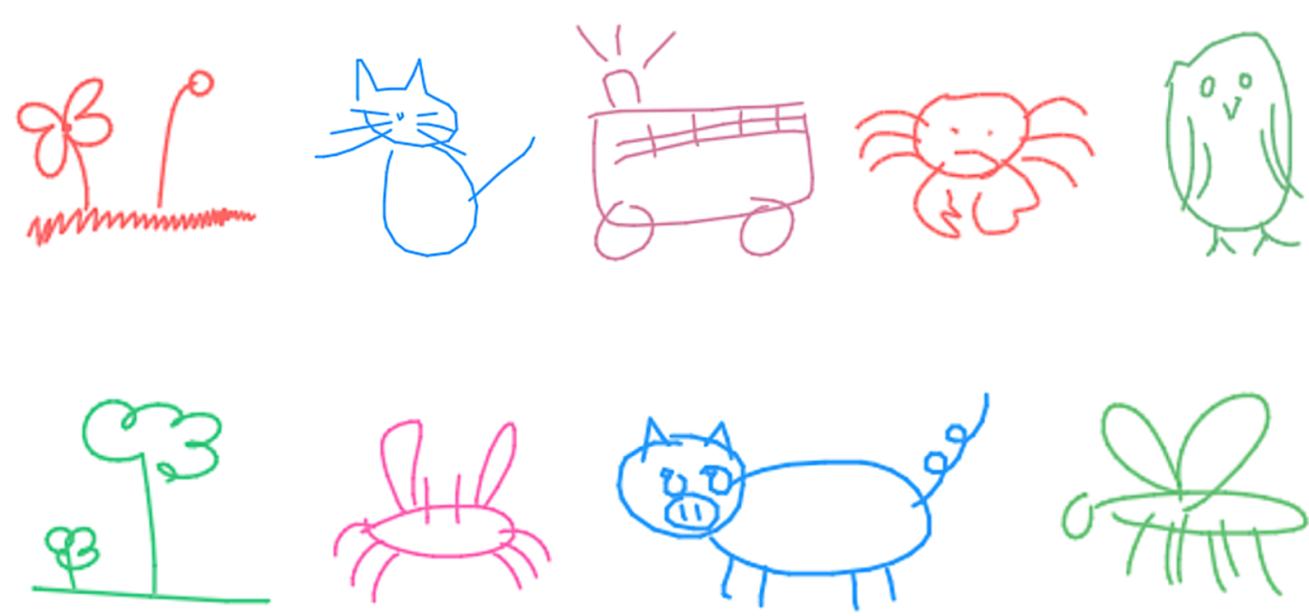
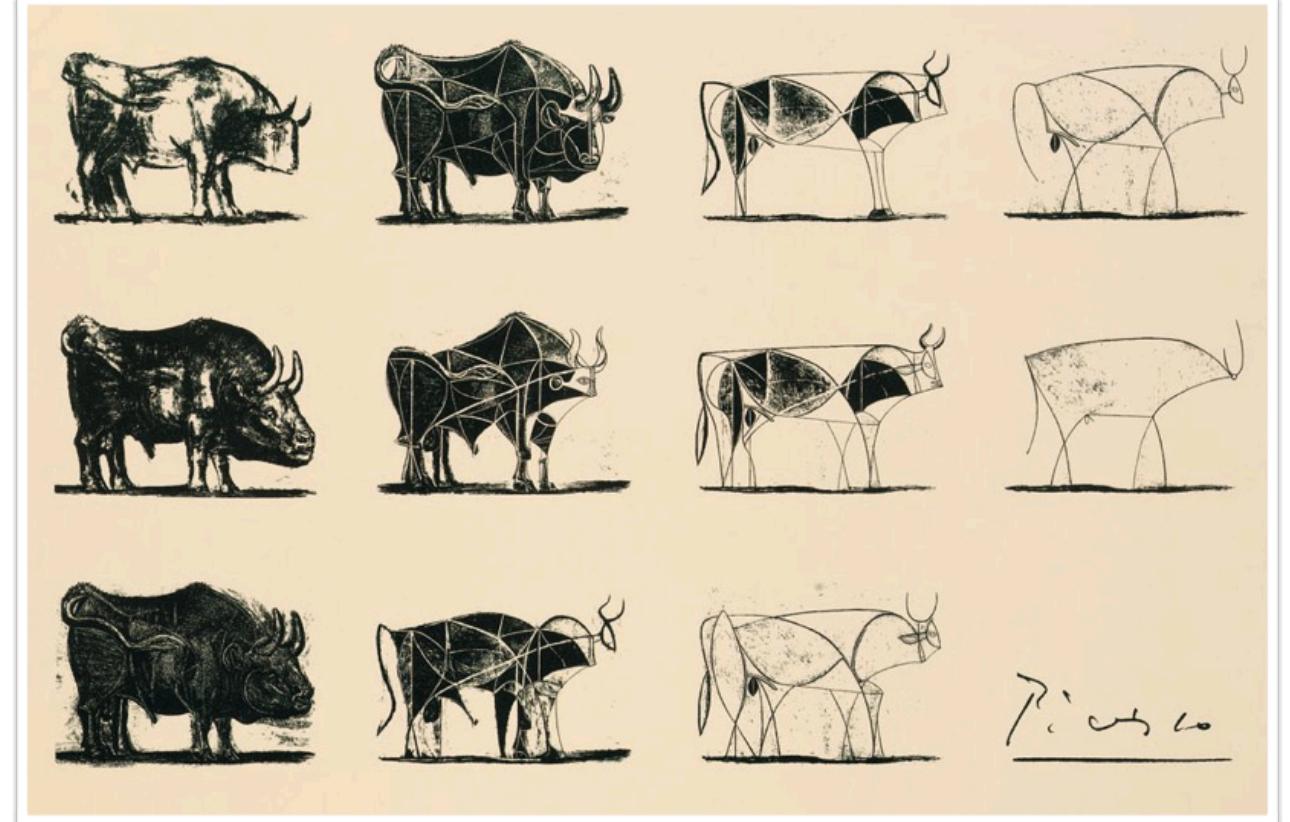


# A Neural Representation of Sketch Drawings

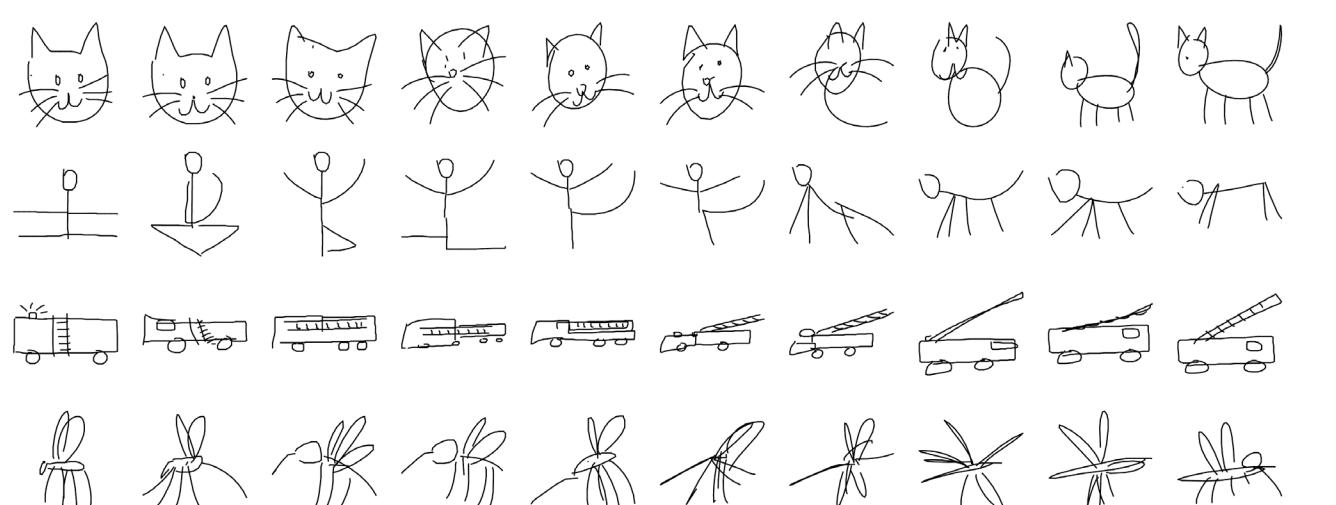
David Ha (hadavid@google.com), Douglas Eck (deck@google.com)



## Motivation



"I never made a painting as a work of art. It's all research." – Pablo Picasso



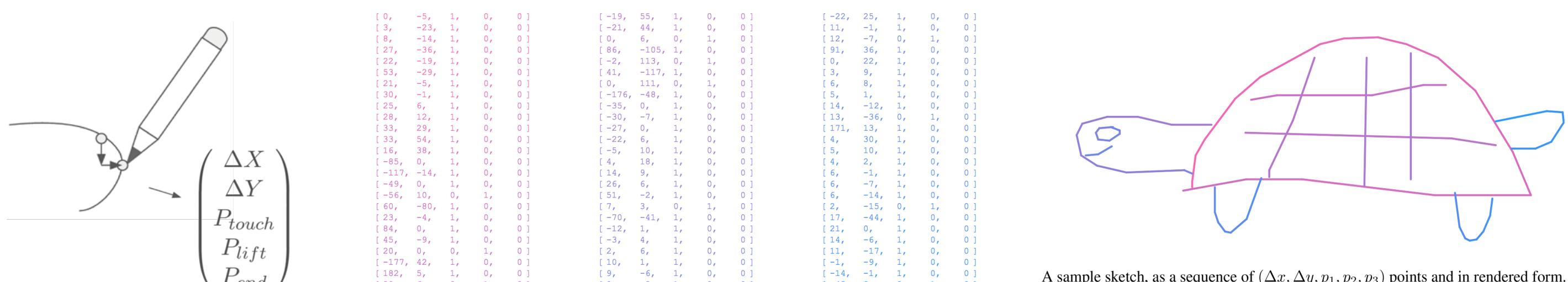
Humans, do not understand the world as a grid of pixels, but develop abstract concepts to represent what we see.

We learn to express a sequential, vector representation of an image as a short sequence of strokes.

In this work, we investigate an alternative to pixel image modelling approaches, and propose a generative model for vector images.

## Quick, Draw! Dataset

[quickdraw.withgoogle.com/data](http://quickdraw.withgoogle.com/data)

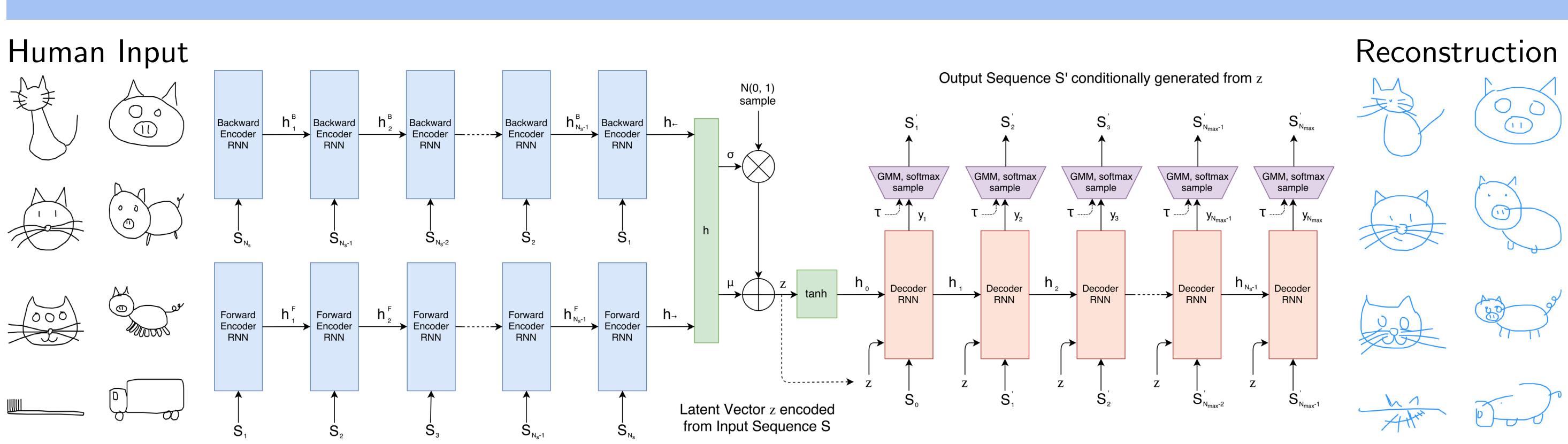


Sketches are represented as a sequence of motor actions controlling a pen. Open sourced dataset of 50M doodles, collected from Quick, Draw! game.

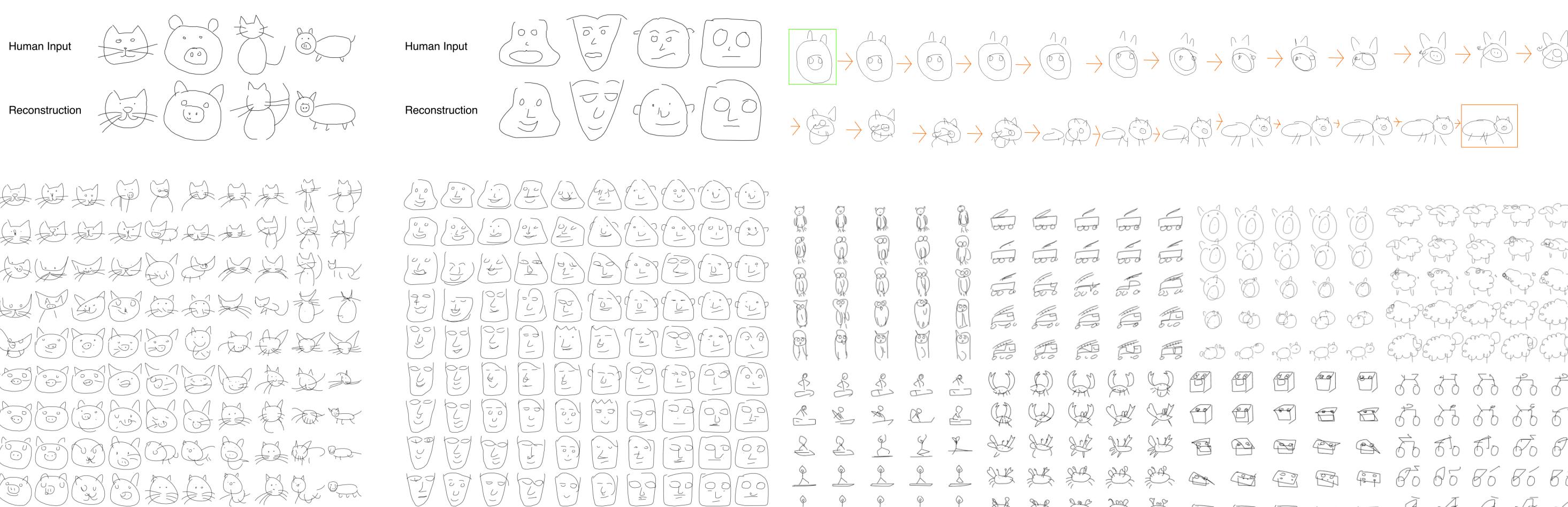


## sketch-rnn

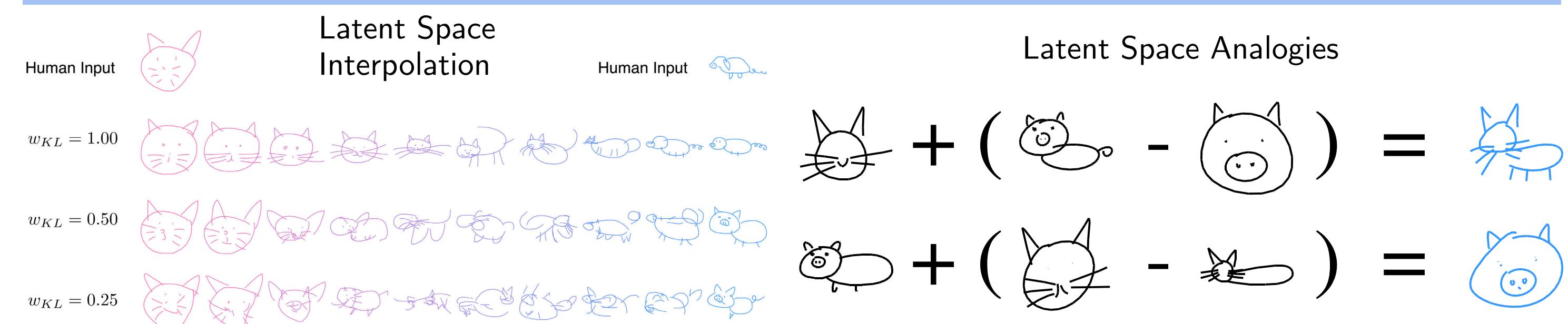
[magenta.tensorflow.org/sketch-rnn-demo](http://magenta.tensorflow.org/sketch-rnn-demo)



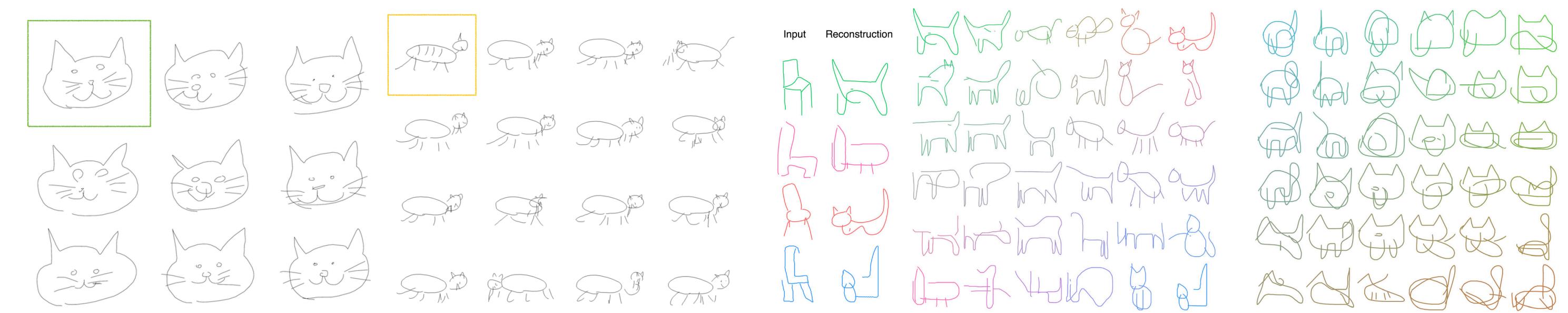
- Seq-to-Seq Variational Autoencoder
- Bidirectional RNN Encoder
- Mixture Density RNN Decoder
- Weighted Loss Function



## Conditional Generation: Latent Space Exploration



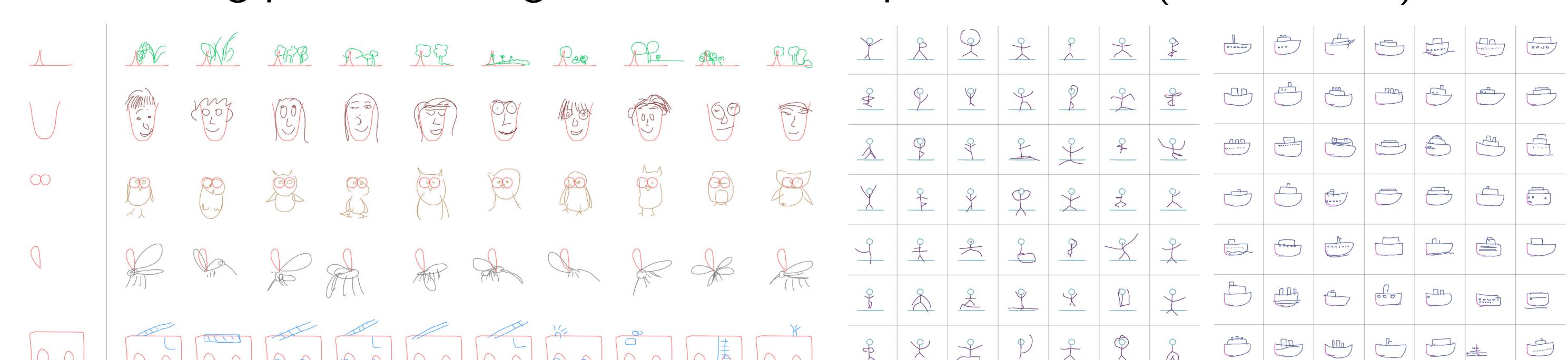
- Sample multiple similar drawings from a single human input sketch.
- Generate a drawing in the style of another class, and also interpolate for more.



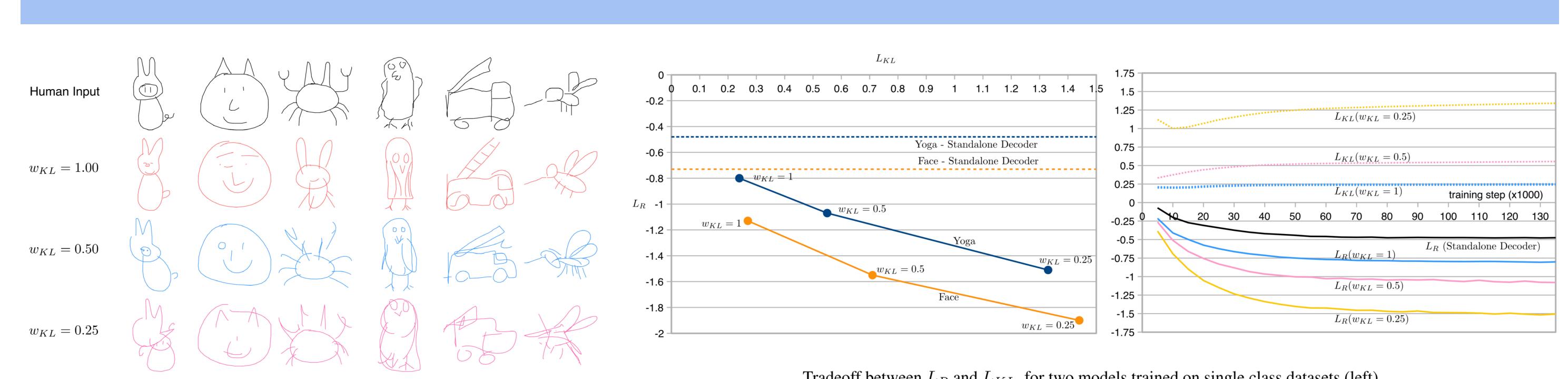
## Unconditional Generation: Use Decoder Only



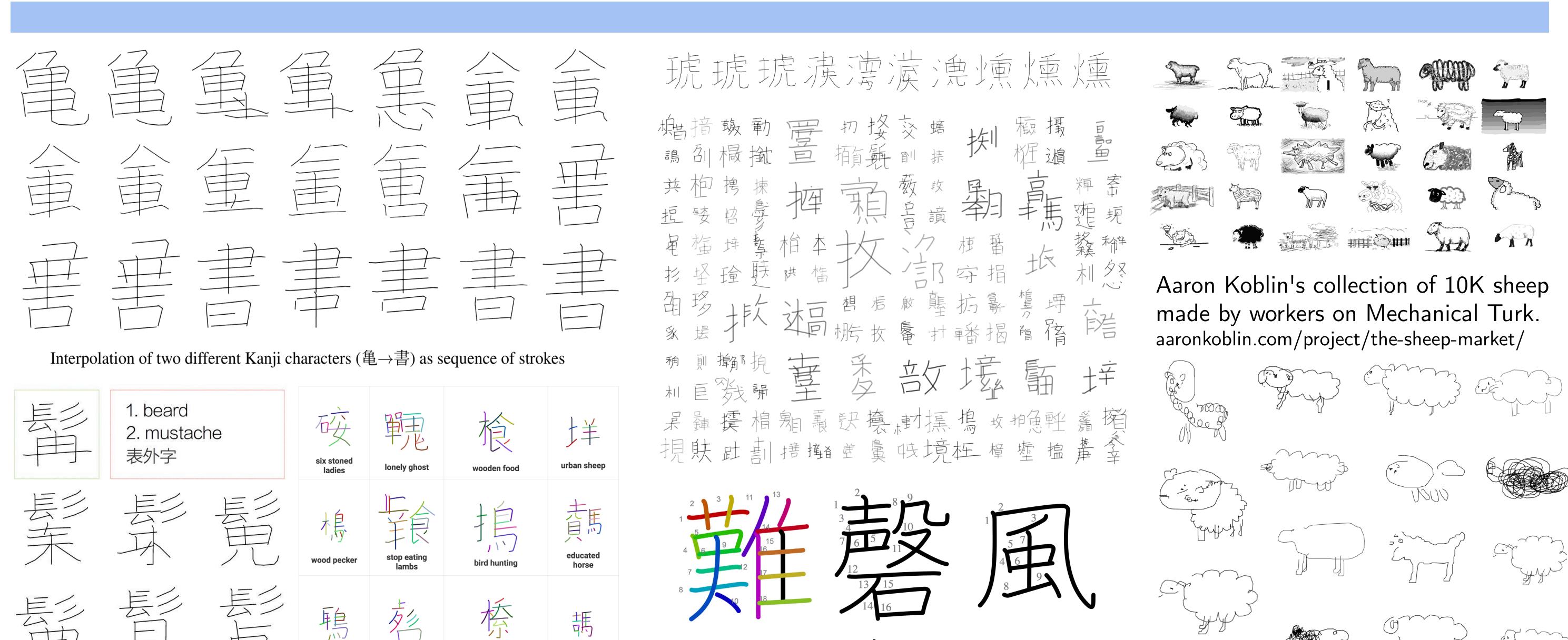
- Varying temperature parameter to control variability of generated sketches.
- Predicting possible endings of various incomplete sketches (the red lines).



## Which Loss Controls Image Coherency?



## Other Datasets: Kanji, Aaron's 10K Sheep Market



## Pixel → Strokes

- We can replace the encoder from a RNN to a ConvNet to read in pixels.
- Chen et al. (2017) showed Pixel to Stroke translation produced good results:

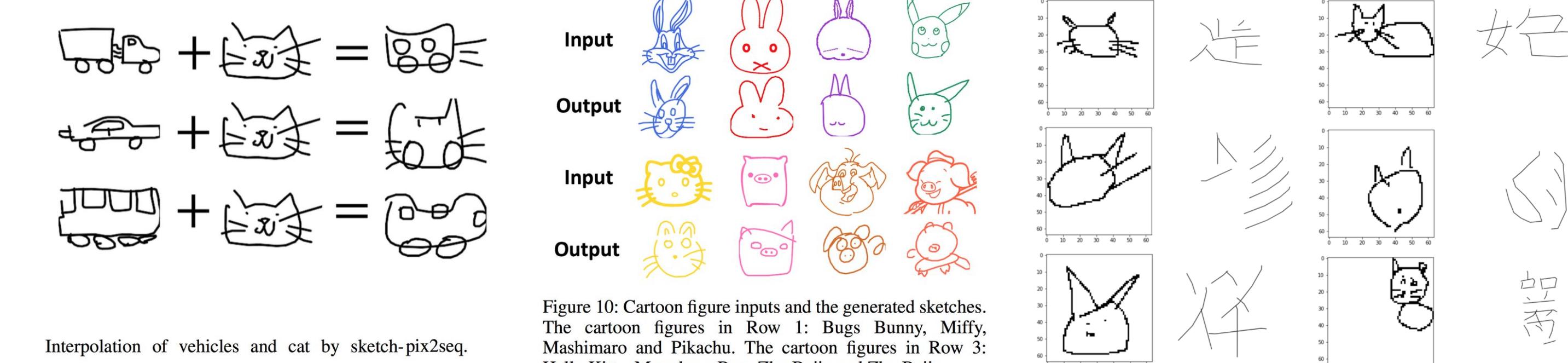
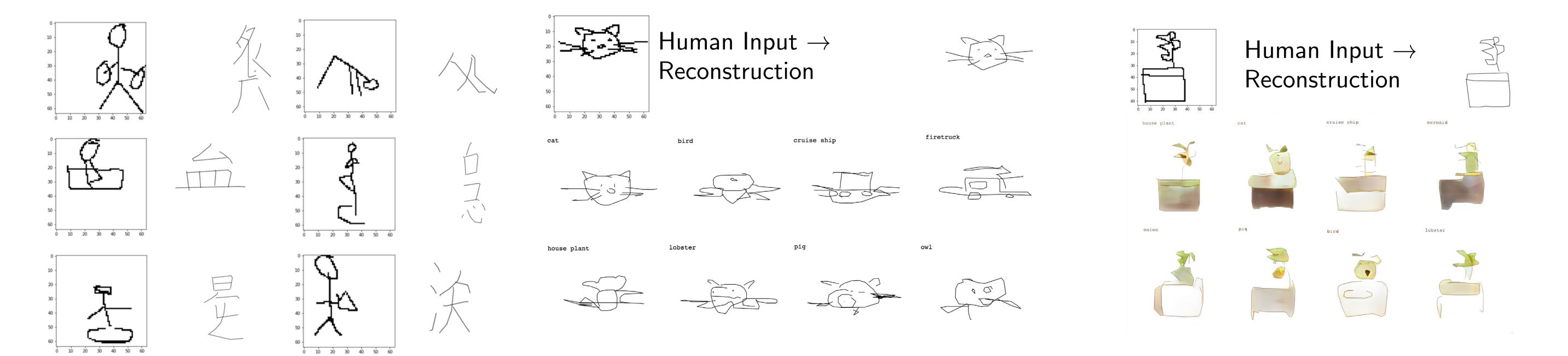


Figure 10: Cartoon figure inputs and the generated sketches. The cartoon figures in Row 1: Bugs Bunny, Miffy, Mashimashi, and Pikachu. The cartoon figures in Row 3: Hello Kitty, Monuko Boo, Zhu Bajie and Zhu Bajie.

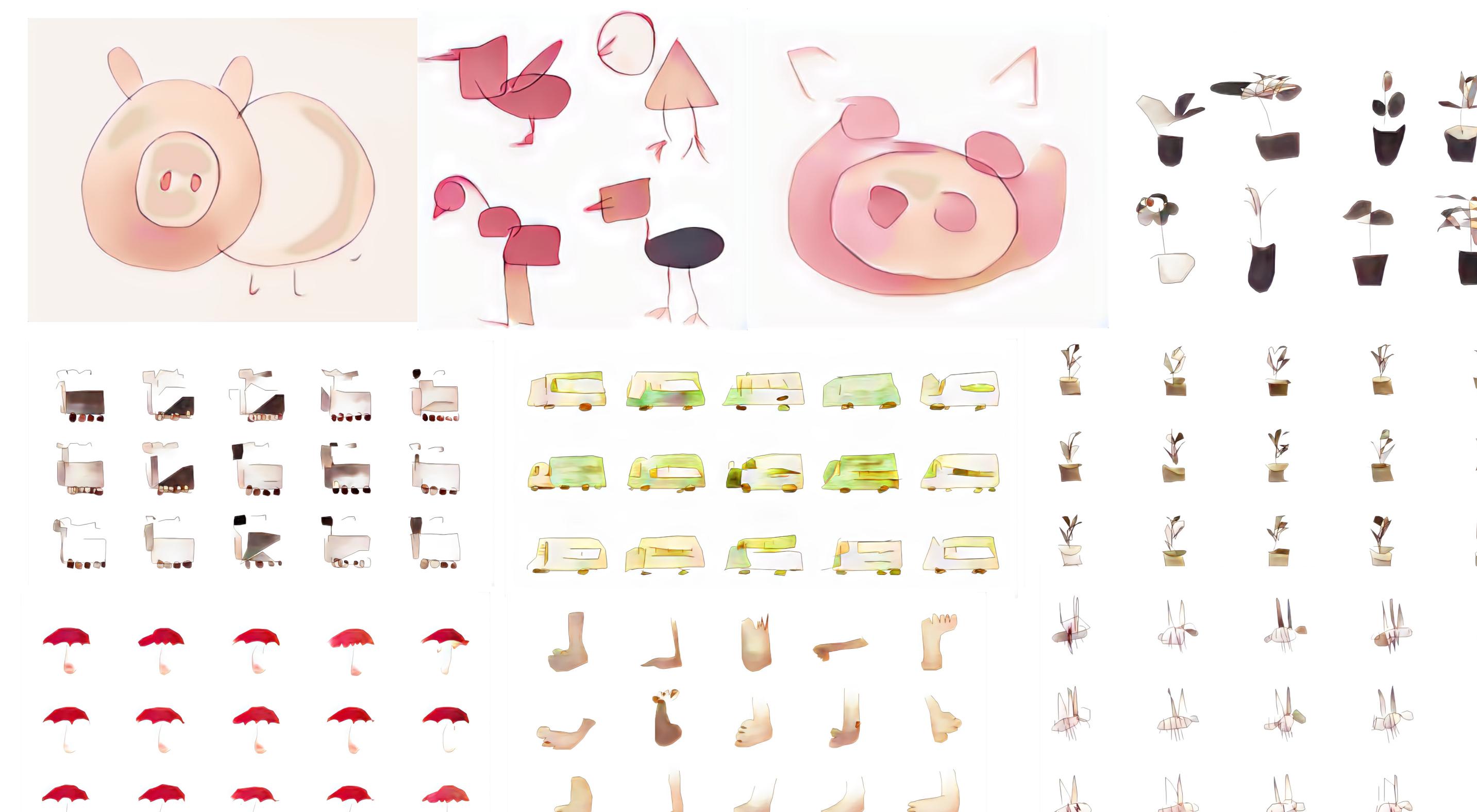
- We can try this technique across domains, such as QuickDraw → Kanji.



- Or convert a pixel image of one QuickDraw class into strokes of another class.

## sketch-rnn with colorization

- Generated sketch drawings can be colorized using image-to-image translation.



## References

- Alex Graves, Generating sequences with recurrent neural networks, 2013.  
 Zhang et al., Drawing and Recognizing Chinese Characters with Recurrent Neural Network, 2016.  
 Bowman et al., Generating Sentences from a Continuous Space, 2015.  
 Chen et al., Sketch-pix2seq: a Model to Generate Sketches of Multiple Categories, 2017.

## Online References

- |                       |   |
|-----------------------|---|
| Fake Kanji Experiment | <a href="http://otoro.net/kanji">otoro.net/kanji</a>  |
| Quick, Draw! Game     | <a href="http://quickdraw.withgoogle.com">quickdraw.withgoogle.com</a>                                |
| Paints Chainer        | <a href="https://github.com/pfnet/PaintsChainer">github.com/pfnet/PaintsChainer</a>                   |
| Paints Transfer       | <a href="https://github.com/lillyasviel/style2paints">github.com/lillyasviel/style2paints</a>         |
| sketch-rnn repo       | <a href="https://magenta.tensorflow.org/sketch_rnn">magenta.tensorflow.org/sketch_rnn</a>             |
| other datasets:       | <a href="https://github.com/hardmaru/sketch-rnn-datasets">github.com/hardmaru/sketch-rnn-datasets</a> |

