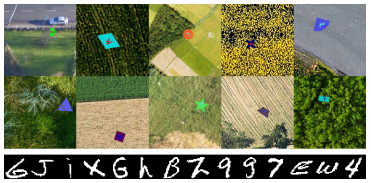
Standardized Object Detection and Classification for Unmanned Aerial Vehicles

Joshua F. Payne, Peggy (Yuchun) Wang
{joshp007, wangyuc}@stanford.edu

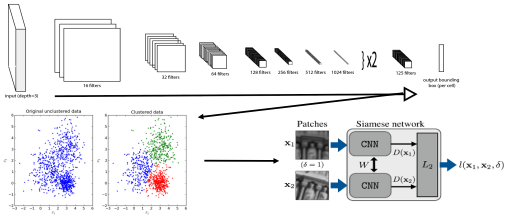
Problem Statement

- **Goal:** Detect, localize, and classify the shape, color, and alphanumeric character of a poster object from an aerial image
- **Datasets:** (1) Extended-MNIST, and (2) created RGB dataset by placing generated geometric shapes with alphanumeric characters onto scraped aerial views of fields. Generated parallel XML files denoting bounding regions.



Approach

We used the YOLO algorithm model to localize object and classify shapes, K-means clustering for segmenting the image and isolating the alphanumeric, and we used both a convolutional neural network and Siamese convolutional neural network for classifying the alphanumeric.



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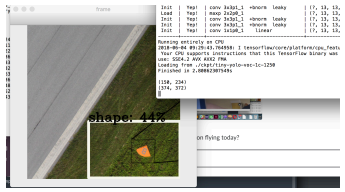
(1) YOLO (You Only Look Once) Network

- Based on Darkflow's Tiny-YOLO model
- Processes 1080x1920 RGB images on a 16GB CPU at ~4 FPS
- Performed well with detection/localization



(2) Segmentation

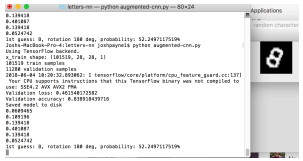
- Segmented the image using k-means clustering (2 clusters):
- Used Euclidean norm to calculate nearest template color to average color of shape:

$$\sum_{i=1}^{2}\sum_{j=1}^{n}||x_i^{(j)} - c_j||^2$$

$$\sum_{i=1}^{3}||x_i - t_i||^2$$

(3) Convolutional Neural Network

- Used 1 convolutional and pooling layers, 2 dense hidden layers
- Augmented data in-training
- Performed even better with real data because of EMNIST Bayes
- Used learning reduction on plateau, dropout
- Used cross-entropy loss function:



$$-\sum_{c=1}^{47} y_{o,c}\log(p_{o,c})$$

(4) Siamese Convolutional Neural Network

- Used positive/negative pairings to learn encodings for alphanumeric images
- Same layers as (3)
- These can be visualized using t-SNE →
- Used contrastive loss function:

$$(1-Y)\frac{1}{2}(D_w)^2 + Y\frac{1}{2}\{max(0, \alpha - D_w)\}^2$$

Results and Discussion

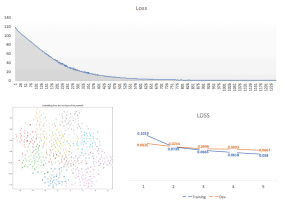
Detection

- Training set: 10,000 images, Dev set: 1,000
- Detection accuracy is good, classification accuracy is poor due to loss function
- Loss convergence, training speed didn't change with addition of classes

Alphanumeric

- Training set: 107,159 images Test set: 5,640 – CNN
- Training set: 200,000 pairs Test set: 10,000 pairs – S-CNN
- Siamese CNN has better accuracy than CNN due to learning encodings

Model	Training Accuracy	Dev Accuracy
YOLO	92.30%	91.80%
CNN	86.99%	84.65%
Siamese	97.68%	97.08%



Future Work

(1) Explore using Siamese CNN model for use in alphanumeric character classification

(2) Implement a separate neural network for classifying the shape, because sometimes YOLO confuses certain shapes with others even if it correctly guesses the bounding boxes for shapes

(3) Tackle tougher problems like search-and-rescue operation detection, infrastructure assessment using 3-D internal models and capsule networks

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