Finding Recyclable Material Using Computer Vision and Support Vector Machine

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Project Description

In 2014, it is estimated that the United States produced 258 million tons of Municipal Solid Waste (MSW).We present here a strategy combining computer vision techniques, machine learning algorithms, and automated drone flight for image capturing to estimate the different types of material present at a waste management site. The software requires the creation of a model using HSV color distribution of segments in training images as features before percentage predictions are made on the categories: tree matter, plywood, cardboard, construction material, and trash bags.

Photo Gathering

To gather images of the waste, we were supplied with a hexacopter mounted with a GoPro Hero 3, and equipped with a PixHawk flight controller.

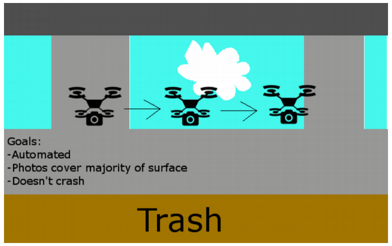

Fig0: Theorized automated image collection of trash

Currently the drone will be piloted by a skilled pilot, while the GoPro takes a photo every two seconds. The gathered pictures are then put into PhotoStitcher to create one large panorama of the waste. This image will then be used by the classification software.

Predicting Trash Categories

Image preprocessing is done on all images for model creation and image classification in order to segment the image. Segmentation of the image takes the following steps: gray scale the image, binarize the image using Otsu's algorithm [3], find the contours using Canny edge detection [2], mark the image with connected components, and apply the watershed algorithm to find segments [2]. Images supplied for training must be filled with the classification category. Only HSV color distribution of each individual segment was used as the instances for training the model. The software uses a support vector machines (SVM) [1] as the machine learning algorithm and openCV computer vision library for image processing [2].

Model Creation

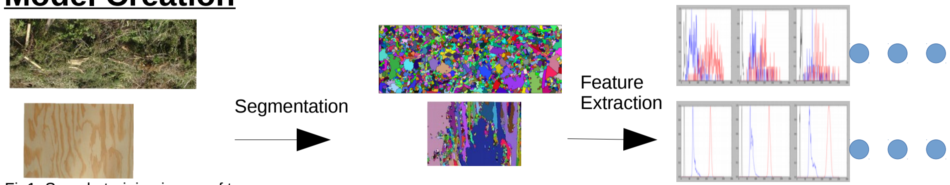

Fig1: Sample training image of tree matter and plywood other categories are not show here

Fig2: Segmentation of training images

Fig3: Extraction of HSV color distribution from each segment found

Image Classification

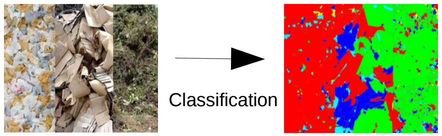

Fig4: Classification of Mixed Sample 1 containing 30% trash bags, 30% cardboard, 30% tree matter

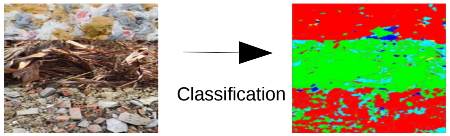

Fig5: Classification of Mixed Sample 2 containing 30% trashbags, 30% tree matter, 30% construction material

Model Creation:

1) Segment in-group images
2) Extract HSV color distribution from each segment
3) Repeat step 1-2 for out-group images
4) Train the model on instance
5) Repeat step 1-4 for all other categories

Image Classification:

1) Segment the image
2) Classify each segment using the models with SVM [1]
3) Color the segments using the model with the best prediction
4) Record pixel percentages of colors as classifications

Results

	construction	tree matter	plywood	Card board	trash bags
all construction	34.37	22.68	26.69	2.04	0
all tree matter	5	74.2	3.53	3.32	0.035
all plywood	22.14	0	54.47	17.12	0
all cardboard	36.38	22.63	20.33	12.11	0.12
Mixed sample 1	43.83	36.78	10.05	3.19	0.62
Mixed sample 2	47.9	34.64	1.52	7.61	0.3

KEY
Blue – construction material
Green – tree matter
Red – plywood
Turquoise – cardboard
Yellow – trashbags

Results

Classification on images containing all construction material, cardboard, and plywood show that the features used for detecting these materials are not distinct enough to distinguish them from each other. Detection of tree matter was the most accurate finding that an image containing all tree matter was 74.2% tree matter. The inability to distinguish construction material, cardboard, and plywood is further shown in the classification of the mixed samples. It can be noticed that tree matter very nearly hit the target percentage of 30% in both images.

Future Work

HSV distribution does not capture shape or orientation of objects and this may be the cause for the low classification accuracy for some categories. Color distribution can also change drastically with different lighting and hues surrounding the object. Object recognition of trash requires the need for additional features that can supply the information an HSV color distribution cannot. Unfortunately, it cannot be said with full confidence the features which would accomplish this task.

Future work should also look to completely automate the flight mechanism of the drone. It has yet to be tested if images captured by the drone at a waste management site would be usable for the classification process.

References

[1] T. Joachims, Making large-Scale SVM Learning Practical. Advances in Kernel Methods - Support Vector Learning, B. Schölkopf and C. Burges and A. Smola (ed.), MIT-Press, 1999.
[2] Bradski, G. (2000). . Dr. Dobb's Journal of Software Tools .
[3] Zhang, Jun & Hu, Jinglu (2008). "Image segmentation based on 2D Otsu method with histogram analysis". Computer Science and Software Engineering, 2008 International Conference on. 6: 105–108.
[4] (2012). PhotoStitcher. Retrieved from https://www.photosticher.com