An Automated Inventory Management System via a Machine Learning Approach

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Presentation Outline

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1. Problem Statement

Problem

Poor inventory management system results in financial losses due to items being misplaced, mislabeled, or even stolen.

Proposed solution

I propose a computer program that can identify objects from an image and subsequently generate a list of the identified objects to a simple csv file.

2. Overview of Approach

- Process labeled images

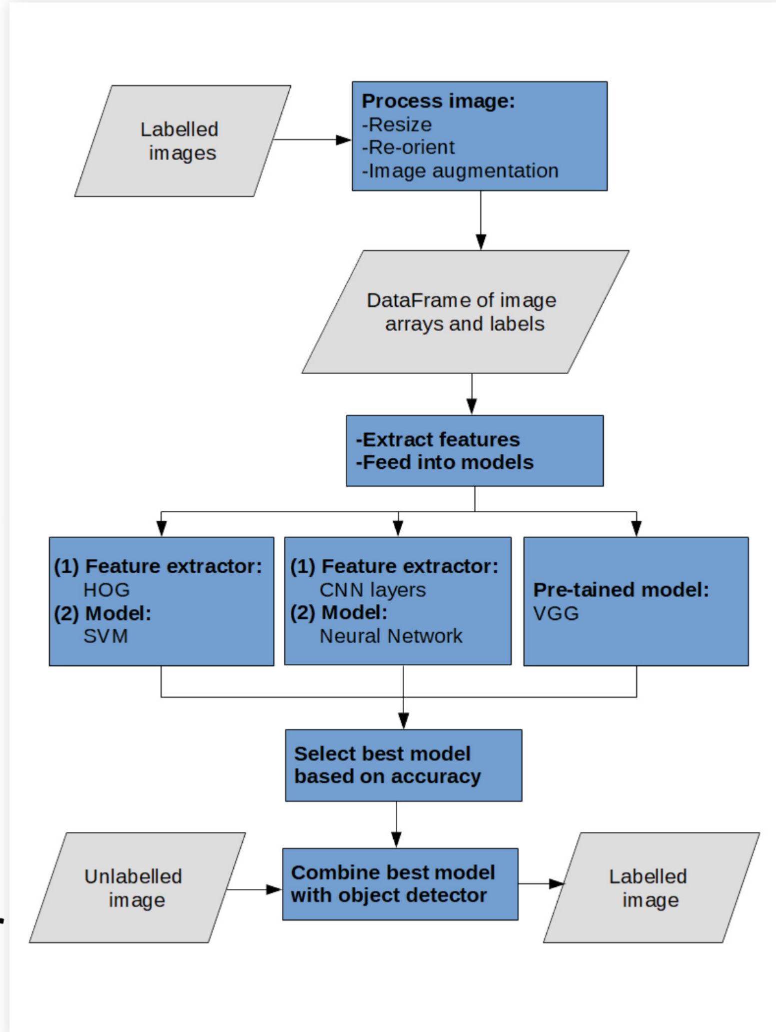
- Develop a model

- Feed processed images into various models

- Select the best model

- Combine the selected model with object detection

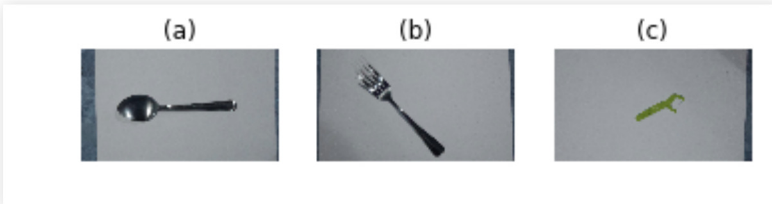
- Detect and label objects, enter information into pandas DataFrame and save as csv.



3 Data Preparation

3.1. The Dataset

- The dataset is pictures of common household objects: (a) spoon, (b) fork, and (c) floss.



- All objects have a high aspect ratio.

- To asses the robustness of deep learning and machine learning models in distingushing similar objects.

3 Data Preparation

3.2. Data Processing

- Make sure that every image is horizontally oriented
- Augment images using the built-in ImageDataGenerator class in keras. Increased number of images from 14 to 112.
- Resize images to 58x103 for VGG16 model
- Transform images to gray and resize to 46x83 for HOG/SVM, NN, and CNN models.
- Images are saved as pandas DataFrame into a csv file, rather than as images.

4. Machine Learning and Deep Learning Models

The following models are considered:

- A combination of histogram oriented gradient (HOG) and support vector machine (SVM)
- Neural Network
- Convolutional Neural Network
- Pre-trained visual geometry group-16 (VGG-16)

4.1. Machine learning [2]

- Use a combination of histogram oriented gradient (HOG) and support vector machine (SVM).
- HOG extracts features from an image.
- SVM correlated image labels with image features.
- Other common alternatives to HOG are scale invariant feature transform (SIFT) and speeded up robust features (SURF).
- SIFT and SURF, however, cannot be used for commercial solutions because they are patented [1].

4.2. Deep Learning [3]

- For the deep learning model, a baseline neural network (NN) model and a convolutional neural network (CNN) model are assessed.
- The baseline NN model consists of just an input and an output layer.
- The CNN model consists of the following: a convolutional layer, a pooling layer, a hidden layer, and an output layer.
- For the CNN model, the convolutional layer is a feature extractor. The NN model uses every data point as input parameters.

4.3. Transfer Learning [4]

- As an alternative, I assess a pre-trained VGG-16 model, which is a sophisticated CNN model.
- Initial assessment of the pretrained VGG-16 model shows that it is unable to recognize any of the three objects (i.e., spoon, fork,and floss). The initial results are as follows:

Predicted label (prob.)	**Actual label**
envelope (14.83%)	floss
spatula (59.51%)	fork
hook (23.42%)	spoon

- This justifies the need to custom-train the model.

4.4. Accuracy of the different models

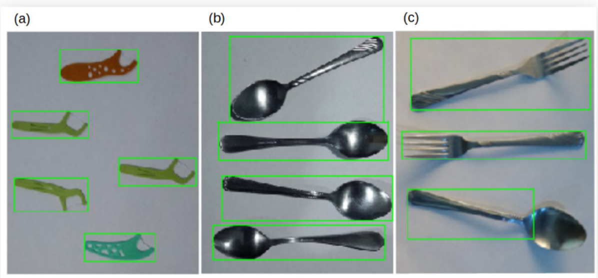
- The accuracy of the different models after training are as follows:

Models	Accuracy (%)
HOG/SVM	96
NN	90
CNN	96
VGG-16	100

- VGG-16 model is 100% accurate. Hence, it is selected.

5. Object Detection and Object Recognition

- Contour detection algorithm is used for object detection.
- The trained VGG-16 model is used for onject recognition.
- The three images below are used for proof-of-concept of this automated inventory management system.



- Note that in figure (c), the contour detection algorithm does not fully detect the spoon.

5. Object Detection and Object Recognition Cont...

- Having detected and recognized objects in a series of images, the program enters the information into a pandas DataFrame, as follows:

	Name	Probability	Image_array
0	floss	[[1.0, 0.0, 0.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
1	floss	[[1.0, 0.0, 0.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
2	floss	[[1.0, 0.0, 0.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
3	floss	[[1.0, 0.0, 0.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
4	floss	[[1.0, 0.0, 0.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
9	fork	[[0.0, 0.76, 0.24]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
11	fork	[[0.01, 0.99, 0.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
5	spoon	[[0.0, 0.0, 1.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
6	spoon	[[0.0, 0.0, 1.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
7	spoon	[[0.0, 0.0, 1.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
8	spoon	[[0.0, 0.01, 0.99]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...
10	spoon	[[0.0, 0.0, 1.0]]	[[[[0 0 0], [0 0 0], [0 0 0], [0 0 0], [0 0 0]...

- The DataFrame consists of three columns: predicted object name, probability, and image array.
- Using data in the 3rd column, each image can be reconstructed and verified with the predicted label.

5. Object Detection and Object Recognition Cont...

- Finally, the DataFrame can be analyzed to yield the number of objects per category, as follows:

```
spoon    5
floss    5
fork     2
Name: Name, dtype: int64
```

6. Summary and Future Works

- A combination of object detection and object recognition algorithms can be used to detect and label objects in a series of images.
- The training images include 14 images from each of the three categories, spoon, fork, and floss.
- To increase the number of dataset from 14 to 112, I use image augmentation.
- VGG-16 model is used for object recognition. An accuracy of 100% is achieved using the trained VGG16 model.
- Contour detection algorithm is used for object detection. Contour detection algorithm does not work well for an image that contain objects that have different aspect ratios or have undefined edge-contrast.
- Future work may include object detection/object recognition from a real-time video using a more sophisticated object detection algorithms, such as you only look once (YOLO) and single shot detection (SSD).

7. References

1. **https://docs.opencv.org/2.4/modules/nonfree/doc/nonfree.html**
2. Gabriel Garrido and Prateek Joshi, "OpenCV 3.x with Python By Example", Packt, 2018, Chpt. 9.
3. Jason Brownlee, "Deep Learning with Python", Machine Learning Mastery, 2018.
4. **https://machinelearningmastery.com/use-pre-trained-vgg-model-classify-objects-photographs/**