**CISC 499 RESEARCH PROPOSAL**

**Multi-class Image Classification and Subclass Identification for Labelled Image Data**

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**Abstract:** Recent advances in computing power and machine learning research have made computer vision commonplace in many modern software applications. We have been provided with an image dataset from a start-up company to help classify their product line of clothes into multiple categories. In this project we will utilize state of the art machine learning techniques to solve this task as a multi-class image recognition problem. A novel unsupervised approach will be used to discover the low-level subclasses of the data given the high-level classes provided in the dataset. The labels identified for the low-level classes will be used to develop and train deep learning models that classify images of clothing based on the extracted features. Lastly, the images in the dataset will be preprocessed to be centered and made square.

**Background:** Supervised multi-class classification algorithms assign a class label for each input example. In the case of images, the training data is in the form of (xi, yi) where each xi is an input image and yi ∈ {1, . . . , K} is the ith class label as stated by Mohamed Aly in [1]. Our goal in a supervised multi-class classification task is to develop and train a model H such that H(xi) = yi for new examples beyond what is in the training data. Currently, state of the art models for multi-class image classification are being developed with neural networks of the convolutional neural network architecture as found by Jianxin Wu in [2].

Clustering is an unsupervised learning task where an observation is assigned to a set of observations which are similar in some sense. The images in the dataset provided have been labelled into 3 classes. Ideally these labels could be further expanded into a full set of 8-12 labels to fully represent all of the types of clothing in the dataset. An approach to find the full set of the classes makes use of a fully unsupervised clustering algorithm to find the partitions of data. Then, using the distributional knowledge of the original labels in each partition, assigning a new class label to each point as seen in Albalate et al’s research [3]. Clustering techniques will be utilized to find the partitions. Image clustering is seen by many as one promising task for the future of computer vision as there are huge volumes of unlabelled image data that could be used for training. Particularly, K-means has been found to be a successful algorithm for clustering images as demonstrated in the work by Caron et al in [5].

**Motivation:** The task presented by our industry collaborator can be broken down into two main components. First, the data labels need to be augmented. Currently the data is labelled and sorted for three classes of images. These three classes identify high level categories which can have multiple subclasses that we would like to identify. Identifying the subclasses will be addressed using an unsupervised learning algorithm to further partition the images within each class. Second, a supervised multi-class classification model needs to be trained to identify which clothing article is in each image. This task has been very thoroughly explored by the research community and there is a large number of model architectures to choose from. I will begin investigating the Inception v3 model by Szegedy et al in [4] that the client currently has implemented while performing a literature review of alternative image classification models to find other advancements in architecture that can increase the accuracy of the model.

Identification of subclasses within a class hierarchy has not been extensively researched by the deep learning community for labelled or unlabeled data. Traditionally, when labels are provided in a supervised or semi supervised learning setting, they are considered to be the lowest level class label for that data point. Refining class labels to be more specific by identifying the subclasses in the dataset has application beyond computer vision in all areas of machine learning.

**Objective:** I plan to research the issues of identifying subclasses of the classes labelled in the dataset by investigating clustering for image data and taking into account the high-level labels when developing the low-level labels. This is the most difficult challenge in the project and the least documented. I will have to use an unsupervised algorithm to cluster the similar images into partitions and then create new labels based on the previous labels that make up the distribution for each partition. I will need to perform preprocessing on the data to make the images square as well as center the subject in each frame. I plan on performing a survey of supervised image recognition model research and compare it with the currently implemented model by the client. I will implement a model with the goal of achieving a final top 1 accuracy of at least 85%. I will investigate the classification accuracy benefits of augmenting the dataset with synthetic data created by performing affine transformations to the images (shifts, scaling, rotating etc.) and use the synthetic data to balance the number of images in each class. If the clustering proves too inaccurate with regards to the subclasses, I can train the model on the original three classes to a high degree of accuracy.

**Project Scope (data and tasks):** The clothing dataset provided by our industry collaborator contains three classes of clothing articles. I propose to first extend these 3 high-level classes of pant, shirt and short to 8-12 further subclasses of clothing. I will create more specific labels from the identified subclasses and create a model that can classify the images using these new labels. Should the new labels prove to be inaccurate I will use the original high-level labels provided with the dataset.

**Deliverables:** Poster, code, group presentation, final report, cleaned and augmented data.

**Timeline:**

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| Dec 1 – Jan 1 | Research clustering with images. Research identifying subclasses within a hierarchy for labelled data. Research multi-class image classification models.  |
| Jan 1 – Jan 31 | Write background literature review and update proposal. Explore and clean the data. |
| Feb 1 – March 1 | Implement clustering algorithm on dataset. Create new labels. Perform preprocessing on the raw images. Get preliminary results. |
| March 1 – March 15 | Implement image classification model for dataset with newly found labels. Augment data using affine transformations. |
| March 15 – April 1 | Iterate through modifications of image classification models with and without augmented data. Record performance effects. Create poster and prepare report. |

**Other work**: I will create a poster for the Creative Computing event and have the software code implemented as a part of the project made available. Due Friday the last week of class.

**References:**

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