Garbage Segregation Using Neural Network

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Abstract:This thesis focuses on analyzing possibilities for automatic waste sorting. Solid waste management is a big challenge in urban areas for most of the countries throughout the world. An efficient waste management is a pre requisition to maintain a safe and green environment as there are increasing of all kinds of waste disposal. The thesis main goal is to automatically classify the images into 2 categories: Plastic and Paper.

I. INTRODUCTION

The main objective of this thesis is to design a part of the system for automatic separation of waste. For example separating plastic from paper and vice versa. Separating different types of plastic from each other is a human labor- intensive process and so far there has been no easy solution. In our country, recyclingcenters do manual process of sorting wastes leading to a high risk of acquiring sickness. This study aims to automate waste segregation and implement a waste delivery system that would minimize human interference in the waste collecting and segregation process. The system intends to optimize this process, providing additional information about the materials on the belt. The information can lead to building a mechanical system separating the materials automatically and decrease the need for human power, making the process more cost effective.

A neural network is implemented which will classify the items from the image to the proper waste separation category –e.g. plastics, paper.

Various neural networks algorithms for image recognition will be implemented. The algorithms will be compared against different datasets. One dataset can be of various categories.

We use Convolutional neural network algorithms to implement this system which is a type of feed-forward artificial neural network where the individual neurons are tiled in such a way that they respond to overlapping regions in the visual fields. Convolutional networks were inspired by biological processes and are variations of multilayer perceptron's designed to use minimal amounts of preprocessing, computing matrices and data structures before application.

II. METHODOLOGY

There are two major approaches for the segregation of waste.
1. By having workers separate the items on the conveyor belt by hand and make different collecting categories.
2. By visual information (typically collected from pre-installed camera) could be used to determine the category of the waste and segregate accordingly.

The first approach is quite tedious and expensive in terms of number of labor and hence is a long process. In the methods employing images, since the items are made singular on the conveyor belt, items can be observed with a camera and system becomes compact and cost reduction becomes possible if the detection of waste items is carried by image processing. Thus the development of the robust and computationally inexpensive technique of segregating waste by using neural networks has been studied

2.1 BLOCK DIAGRAM
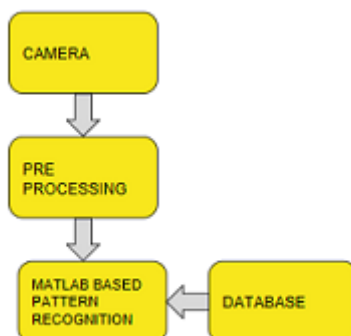
1. The camera is connected to the server through either local wireless network or through the Internet.
2. The server is the second component. It includes a database, detection module and web service and event handler. The server collects images from visual nodes, feeds them to the detection module and collects and stores its output in the database and provides web service for front -end applications to get information from the database.
3. The third element is the front end that presents which type of item has been detected and accordingly segregated .

2.2 SERVER

The server in our system has four responsibilities: First, it is to host the database. A relational database is used in this system. It stores separate tables for different materials where each element of the table corresponds to an item. Second, it is collecting data from cameras. Cameras can be connected to the server in a local network or can be connected through Internet. If cameras do not use HTTP protocol, a local communication protocol will be used on the server. If they do, requests and responses can be done with HTTP. If the cameras are connected to Internet, there is no need for the server

to be located close to visual node and a server on the cloud is a valid option. Third, it is serving a web-service. It bridges the database to our system's front end .Finally, it feeds the images from visualnodes to the detection module and receives detection module predictions.

2.3 DATASET

The original dataset comprises of 400 images each for plastic and paper. We have selected 100 images each from plastic and paper dataset. Then these images were stored in separate folders and then fed to the CNN. The CNN then decides and selects images for training and validation.

1. Training: 150 images were selected for training randomly. 2. Validation: 50 images were selected for validation randomly.

III. FEATURE EXTRACTION

The original image which is taken by camera is processed to detect edges. The colour image must be transformed into various forms to obtain a edge image.

3.1 log transformation

Logarithm transformation maps the narrow range of low tray-level values in the input image into wider range of output levels. It expands the values of darker pixels in an image while compressing the higher-level values. The general form of log transform is: $s = c.*\log_{10}(1 + m)$ Where c is a constant and m is assumed to be greater than 0.Note that m is size of the pixel that is 28. The log function has the important characteristic that it compresses the dynamic range of image with large variations in pixel values.

3.2 Pre-processing

Before feeding the images to the CNN, we perform pre-processing which includes steps of converting the RGB images into black and white. Allimages have to be of the same size and must be reduced to 28x28 pixels because it becomes easier for the neural network to perform on similar equal size images. We then remove noise from images by using denoising techniques and then deblur the images. After pre-processing we feed the dataset to the neural network.

IV. CNN

A convolutional neural network (CNN or Convolutional Net) is one of the most popular algorithms for deep learning, a type of machine learning in which a model learns to perform classification tasks directly from images, video, text or sound. Convolution neural networks are deep artificial neural networks that are used primarily to classify images (e.g. name what they see), cluster them by similarity and perform object recognition within scenes. The CNN design consists of an input and output layer, as well as many hidden layers. The hidden layers of a CNN has: 1. Convolution Layer 2. Pooling Layer 3. Rectified Linear Unit Layer 4. Fully Connected Layer

4.1 Convolution layer

Think of a convolution as a way of mixing two functions by multiplying them.

Asthefilterissliding, orconvolving,aroundtheinputimage, itismultiplyingthe values in the filter with the original pixel values of the image. So now you have a single number.Now, there are 2 main parameters that we can change to modify the behaviour of each layer. After we choose the filter size, we also have to choose the stride and the padding. Stridecontrolstheamountofshiftthatthefiltertakeseachtime. Imagepaddingintroduces new pixels around the edges of an image. The border provides space for annotations or acts as a boundary when using advanced filtering techniques. This is done so that the information in the corers are not lost during convolution process. If you have a stride of 1 and if you set the size of zero padding to ZeroPadding = $(K + 10)2$. Where K is the filter size, then the input and output volume will always have the same spatial dimensions. The formula for calculating the output size for any given convolution

4.2 Poolinglayer

ItiscommontoperiodicallyinsertaPoolinglayerin-betweensuccessiveconvolutionlayers in a Convolutional Net architecture. This is basically takes a filter (Normally of size 2 x 2) and a stride of the same length. It then applies it to the input volume and outputs the maximum number in every sub region that the filter convolves around.

4.3 RectifiedLinearUnitLayer

After each convolutional layer, it is convention to apply a nonlinear layer (or activation layer) immediately afterward. The purpose of this layer is to introduce nonlinearity to a system that basically has just been computing linear operations during the convolutional layers. The ReLU layer applies the function $f(x) = \max(0,x)$ to all of the values in the input volume. In basic terms, this layer just changes all the negative activations to 0. This layer increases the nonlinear properties of the model and the overall network without affecting the receptive fields of the convolutional layer.

4.4 FullyConnectedLayer

Finally, after several convolutional and max pooling layers, the high -level reasoning in the neural network is done via fully connected layers. Neurons in a fully connected layer haveconnectionstoallactivationsinthepreviouslayer, as seeninregularneuralnetworks. Their activations can hence be computed with a matrix multiplication followed by a bias offset.

4.5 Additional Layers

4.5.1 SoftmaxLayer

A softmax layer applies a softmax function to the input. The softmax function squashes the outputs of each unit to be between 0 and 1, just like a sigmoid function. But it also divides each output such that the total sum of the outputs is equal to 1. The loss function of softmax classifier is defined as:

$$(x + a)^n = \sum_{k=0}^{n} \binom{n}{k} x^k a^{n-k}$$ the softmax function is often used in the final layer of a neural network based classifier. Such networks are commonly trained under a log loss (or cross-entropy) regime, giving a non-linear variant of multinomial logistic regression.

4.5.2 ClassificationLayer

A classification output layer holds the name of the loss function the software uses for training the network for multi class classification, the size of the output, and the class labels.

4.6 WorkingofConvolutionalNeuralNetwork

1. Wepassaninputimagetothefirstconvolutionallayer. Theconvolutedoutputisobtained as an activation map. The filters applied in the convolution layer extract reliever featuresfrom the input image to pass further.

2. Each filter shall give a different feature to aid the correct class prediction. In case we needtoretainthesizeoftheimage, weusesamepadding (zeropadding), otherwisevalid padding is used since it helps to reduce the number of features.

3. Pooling layers are then added to further reduce the number of parameters.

4. Several convolution and pooling layers are added before the prediction is made. Convolutional layer help in extracting features. As we go deeper in the network more specific features are extracted as compared to shallow network where the features extracted are more generic.

5. The output layer in a can as mentioned previously is a fully connected layer , where the input from the other layers is flattened and sent so as the transform the output into the number of classes as desired by the network.

6. The output is then generated through the output layer and is compared to the output layer for error generation. As loss function is defined in the fully connected output layer to compute the mean square loss. The gradient of error is the calculated.

7. The error is then back propagated to update the filter (weights) and bias values.

8. One training cycle is completed in a single forward and backward pass.

V. RESULTS AND DISCUSSION

	No. OF IMAGES		ACCURACY(%)
	PAPER	PLASTIC	
TRAINING	150	150	82%
VALIDATION	50	50	90%

VI. ACKNOWLEDGMENT

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