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Real-Time Waste Object Segregation Using Convolutional Neural Network

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Abstract: The increasing number in solid waste in the urban area is becoming a great concern, and it would result in environmental pollution and may be dangerous to human health if it is not properly organized It is important to have an advanced or intelligent waste management system to manage a variety of waste material. One of the most important steps of waste management is the separation of the waste into the different components and this process is normally done by handpicking. To simplify the process, we propose an intelligent waste material classification system, which contains 14 million images belonging to 1000 classes (VGG16) Convolutional Neural Network model which is used to pre-train dataset and serves as the extractor, and Support Vector Machine (SVM) which is used to classify the waste into different groups or types such as glass, metal, paper, and plastic etc. The proposed system is examined on the trash image dataset which was developed by Karen Simonyan and Andrew Zisserman, and is able to achieve an accuracy of 92.7% on the dataset. The separation process of the waste will be faster and intelligent using the proposed waste material classification system without or reducing human involvement

Keywords: Convolutional Neural Networks, Pre-train Model, Waste Separation, Automation, Machine Learning, Support Vector Machine

• Introduction:

As the population living in urban areas increases rapidly throughout the years, there are a lot of challenges taken place in cities, especially in the waste management system. Waste management system, also considered as a waste collection system, requires several steps and actions to waste disposal, including the collection, transport, monitoring and regulation of the whole process. The methods to manage waste between urban and rural areas are different. Generally, the best solution to manage collected waste is to reuse and recycle them. However, the cost of effective waste management is high,

which requires cooperation from both authorities and users. A lot of efforts have been made by the government to improve the waste management system and nevertheless, this is still a big problem in every country, especially in urban cities. Deep neural network results showed better accuracy in a series of relevant benchmark competitions in machine learning and pattern recognition. Deep learning is a form of machine learning that permits the learning of computers from experience. Deep learning allows multiple layers of processing in computational models to understand a data presentation with multiple layers of abstraction. These technologies help us to build cutting-edge technology in fields such as voice recognition, visual objects, drug discovery and genomics in numerous different field There is a class of deep learning called convolutional neural network (CNN) which is applied mainly for image processing, object recognition and so on The integration of CNN in a smart waste management system can highly enhance the performance of waste classification and categorize them correctly, saving resources and reducing the waste generated in the world this paper presents a smart waste management system that detects and categorize the different types of waste and places them into a specific compartment. The VGG-16 has been applied to the system for detection purposes and Support Vector Machine (SVM) which is used to classify the waste into different groups.

• Overview:

The world bank report showed that there are almost 4 billion tons of waste around the world every year and the urban alone contributes a lot to this number, the waste is predicted to increase by 70% in the year 2025. According to in the next 25 years, the less developed countries' waste accumulation will increase drastically. With the increase in the number of industries in the urban areas, the disposal of the solid waste is really becoming a very big problem, and the solid waste includes paper, wood, plastic, metal, glass etc. the main method of managing the waste is landfilling, which is inefficient and costly and polluting natural surrounding Another common way of managing waste is burning waste and this method causes the air pollution and some hazardous materials from the waste spread into the air which can cause cancer to the people hence it is necessary to recycle the waste properly to protect the surrounding and human beings' health, and we need to separate the waste into the different sections which can be recycled using different ways

1. DEEP LEARNING:

Machine learning is used to analyze, understand and identify a pattern in the data Machine learning helps the machine to make decisions on its own without any human intervention using its experience. To understand the relationship between input and output it uses data to feed an algorithm. Deep learning also is known as deep structured learning or hierarchical learning is a subset of machine learning which makes use of deep neural networks because it mimics the network of neurons in the brain. Deep learning can be used in a task involving adaptive learning like computer vision, image recognition, speech recognition, natural language processing medical image analysis, etc. as well as in cognitive learning such as learning the features, characteristics, and attributes with the help of good algorithms which can learn on its own Deep learning architecture is deep neural networks, deep belief networks, recurrent neural networks and convolutional neural networks that represent probability grading . In convolution neural network architecture layers are stacked upon each other, this helps to solve problems of classification and representation through constant learning Each layer learns minute details from the picture then the next layer combines the previous layer knowledge to make complex information feature extraction is done here by using a filter; the filter finds the matching features from the picture hence it is automatic. To learn data representation, it processes multiple layers through computational models. The back propagation algorithm is used to discover complex structures in huge data sets and represents variation in inner parameters of a machine that are used to determine the representation of each layer from the depiction of the previous layer Weights used for recognizing any objects are combined in backpropagation.

2. CONVOLUTIONAL NEURAL NETWORK:

Convolutional Neural Network (CNN) is prominently used for image analysis. Its hidden layers called convolutional layers to make it more special. Each of them convolutional layer contains a set of filters. These filters detect patterns or features in the images. The CNN eventually differentiates features within the image from one another. Convolutional neural networks have been used by other researchers to analyze digital images for object recognition or classification. Instead of primitive methods such as filtering by a hand-engineered process, after proper training, CNNs can filter/categorize images into different classes based on the inputoutput pairs. The architecture of a CNN is similar to the internal connecting system of neurons in the human brain. A simplest CNN has the following layers:

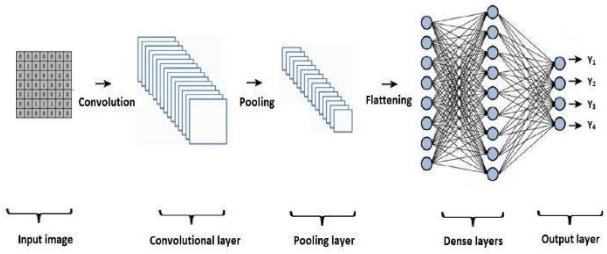

Fig . Design of a Convolutional Neural Network

2.1. CONVOLUTIONAL LAYER:

A convolutional layer extracts features of images by using filters. Filters are small matrices of dimensions of our wish filled with random values. These filters detect patterns by striding over the input images after which we get the resultant feature map which is passed to the next layer.

2.2. POOLING LAYER:

In this layer, a window normally a size of 2x2 is placed over the feature map and the maximum value is selected in the window neglecting all other values. It results in a decreased picture scale.

2.3. FULLY CONNECTED LAYER:

The actual image recognition and classification both happens in this sheet. The shrink images are taken and inserted into a single vector. This vector is compared and the image is classified with the vectors obtained from the trained images.

3. VGG-16:

It is a Convolutional Neural Network (CNN) model proposed by Karen Simonyan and Andrew Zisserman at the University of Oxford. The idea of the model was presented in 2013, but the actual model was submitted during the ILSVRC ImageNet Challenge in 2014. This model achieves *92.7% top-5* test accuracy on ImageNet dataset which contains *14* million images belonging to 1000 classes.

• ARCHITECTURE:

The input to any of the network's configurations is considered to be a fixed size 224x224 image with 3 channels RGB. The only preprocessing done is normalizing the RGB values for every pixel. This is achieved by subtracting the mean value from pixel. Image is passed through the first stack of 2 convolution layers of the very small receptive size of 3x3, followed by ReLU activations. Each of these two layers holds 64 filters; The convolution stride is fixed at 1 pixel, and the padding is 1 pixel this configuration preserves the spatial resolution; the size of the output activation map is the same as the input image dimensions the activation maps are then passed through spatial max pooling over a 2x2 pixel window with a stride of 2 pixels this halves the size of the activations thus the size of the activations at the end of the first stack is 112x112x64 the activations then flow through a similar 2nd stack, but with 128

filters as against 64 in the first one Consequently the size after the second stack becomes 56x56x128 this is followed by the third stack with three convolutional layers and a max pool layer The number of filters applied here are 256, making the output size of the stack 28x28x256 This is followed by two stacks of three convolutional layers, with each containing 512 filters the output at the end of both these stacks will be 7x7x512 the stacks of convolutional layers are followed by 3 fully connected layers with a flattening layer in-between The first 2 have 4096 neurons each and the last fully connected layer serves as the output layer; has 1000 neurons corresponding to the 1000 possible classes for the ImageNet dataset the output layer is followed by the SoftMax activation layer used for categorical classification.

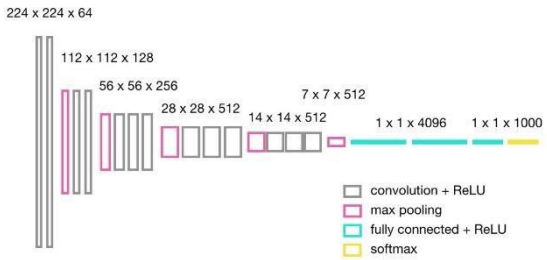

Fig . The architecture of VGG16

- **Conclusion:**

In conclusion, we present a waste classification system that is able to separate different components of waste using the ML tools. This system can be used to automatically classify waste and help in reducing human involvement and preventing infection and pollution. From the result, when tested against the trash dataset, we got an accuracy of 87 percent. The segregation process of the waste will be faster and intelligent using our system without or reducing human intervention. If additional image is added to the dataset, the system accuracy can be improved in the future, we will improve our system to be able to categories more waste item, by turning some of the parameters used.

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