AN AUTOMATIC CLASSIFICATION METHOD FOR ENVIRONMENT

FRIENDLY WASTE SEGREGATION USING DEEP LEARNING

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Abstract--**Recent enforcement of law by the Indian government for the welfare of sanitation workers has raised the need for an automated system in waste management. The existing garbage disposal system in India consists of unclassified waste collected from homes which are then segregated at a station manually. This segregation of solid waste done by manual labor can bring about many health hazards for the waste sorters in addition to being less efficient, time consuming and not completely feasible due to their large amount. In our paper, we have proposed an automated recognition system using Deep learning algorithm in Artificial Intelligence to classify objects as biodegradable and non-biodegradable, where the system once trained with an initial dataset, can identify objects real-time and classify them almost accurately. Biodegradable waste is used to generate power, enrich soil and act as food to animals. This process does not harm the earth making it valuable, ecologically safe and helps us to protect our environment, rich ecosystem and human inhabitants in future.**

Index Terms—**Garbage segregation, Deep learning**

I. INTRODUCTION

Cities are becoming increasingly aware of the problems related to conventional methods of waste collection. In general, waste may be defined as unwanted materials that are not prime products which are of no further importance to human in their actual form.

Waste may be generated during the extraction or processing of raw materials, consumption of final products and human activities. They can thus be classified as industrial waste, clinical waste and domestic waste. Improper disposal of garbage has many hazards affecting all forms of life leading to contamination of air, water and soil and also causes dangerous diseases to human beings.

The trend to instil automated waste segregation systems into new housing development projects is rising and serves for leading the way in implementing this type of technology. Statistics show that UK produces 330 million tonnes of waste a year [4] and estimates show that in 2007, 480,000 fewer tons of CO2 were emitted due to separate collection and composting of 833,000 tons of organic materials [5]. This shows us the need for segregating and composting garbage on a larger scale.

II. OBECTIVE

The existing garbage disposal system in India requires manual labour for segregation of its waste. With a population of 1.252 billion (2013) people in India, relying solely on the segregation done manually is not healthy. It leads to an unhealthy environment as well as can bring about many hazards for the labourers.

Our objective is to bring about an automated process to the existing laborious method where the process is faster, cleaner and does not affect the ecosystem. The biodegradable

products must be put to decompose and the rest, recycled. Resources must be saved and they must not be extinguished.

III. EXISTING SYSTEM

The prevailing garbage disposal system in India consists of unorganized waste collected from habitats which are then segregated at a station. The segregation is done by manual labor which has many health mishaps for the laborers and is time consuming and also requires financial share to the workers. Uncontrolled dumping of waste on outskirts of towns and cities has created overflowing landfills which are not only impossible to reclaim because of the disorder manner of dumping but also has acute environmental implication in terms of ground water pollution and contribution to Global warming. This has been found to reduce the average life span of the manual segregators.

A new concept [1] uses a hardware component that can sort waste at the initial stage thus making waste management more powerful and fruitful. The designed system sorts wastes into three different categories, namely metal, dry and the wet waste. A simple 8051 microcontroller forms the heart of the system. It controls the working and timing of all the sub sections so as to sort the waste into the three primary categories.

2 The main disadvantage in the existing system is that, segregation of the waste consumes time. Size of the waste must be less than or equal to the dimension of the funnel i.e. 20cm X 20cm. E-waste, Sanitary waste and medical waste cannot be segregated by the proposed system as there are certain rules and regulations specified by government to be followed for their segregation. It also uses complex hardware components for segregating the garbage.

IV.PROBLEM DEFINITION

The increasing population of India poses serious threats like limitation of living space, education and employment. But another serious problem is the enormous amount of waste generated each minute by an individual. Solid waste management is a big challenge in urban areas for most of the countries throughout the world. An astounding tones of waste is generated each day in India. But only 5% of this large amount of waste is recycled. One possible solution for this problem could be segregating the waste at the starting stage itself. The segregation of the waste is to be properly managed so as to minimize the risks to the health and safety of patients, the public, and the environment.

The economic value of waste is best known when we segregate the waste products. Currently there is no effective system for segregation of various types of wastes at a household level. The purpose of our project is to make a simple, low cost and user friendly segregation system for urban households to waste management process more effective in India.

V.DEEP LEARNING

Deep learning is an arising field of Machine learning which is still in its research and mainly aims in bringing machine learning even more nearer to one of its focuses: Artificial Intelligence. Machine learning concentrates on tasks such as recognising the images, converting speech to text, recognition of speech and visual object, drug discovery, face detection and recognition, weather forecast etc. Deep learning techniques are used more in these applications where adaptive learning is done. Deep learning can do cognitive learning such as learning the features, characteristics and attributes with the help of good algorithms which can learn by itself and deep architecture. The family of deep learning has been increasing which includes neural networks, various unsupervised and supervised learning algorithms for recognising feature such as Deep Belief Network, Deep convolutional Neural Network and Recurrent Neural Network and models which represent the probability of the hierarchy.

Deep Structured Learning which is also termed as Deep Learning or Hierarchical Learning has risen as one of the fastest growing areas of Machine Learning which focuses on trying to mimic all the tasks that a normal human brain can perform.

It has the capacity to process complex data given as input and results in giving the predicted output through effective recognition. Deep learning allows processing of multiple layers through the computational models in order to learn data representations with abstraction of many layers. Deep learning uses the back propagation algorithm to discover complex structures in huge data sets and represents how a machine should vary its inner parameters that are used to determine the representation of each layer from the depiction of previous layer. Deep architecture has networks with multiple layers and the adjacent layers are in some way connected with each other. It is mainly used in solving the problems of representation and classification through constant learning. Perceptron which has some weight combines all the known features for recognising the objects.

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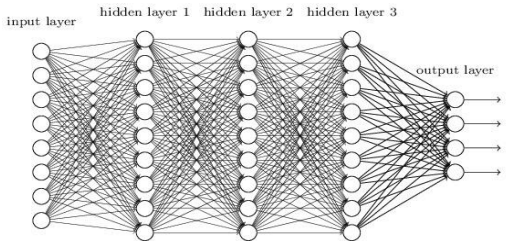
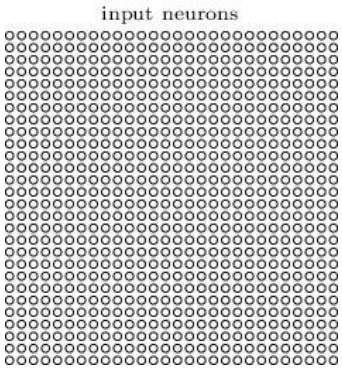
A.DEEP LEARNING IN OBJECT RECOGNITION:



For each pixel in the input image, the intensity of the pixel is encoded is the value for a corresponding neuron in the input layer. For the 28×28pixel images, there are 784 neurons which are given as the inputs. The output of the network can be an input image based on the trained network‟s weights and biases.



Each neuron in the first hidden layer will be connected to a small region of the input neurons. The region in the input image is called the local receptive field for the hidden neuron which acts as a window for the input pixels. Each connection learns a weight by itself when trained and the hidden neuron learns an overall bias too.

VI. PROPOSED IDEA

The proposed idea mainly focuses on the identification and classification of the waste that is dumped in the garbage. Usually, unsegregated waste is dumped in a landfill and made to decay which however takes hundreds of years in the case of non-biodegradable waste.

Our project proposes an idea where a computer on its own is able to recognize the waste without human intervention based on the material of the item, irrespective of its shape and size, easily and classify them. Our proposed system can learn by itself and thus can constantly update itself in case of new materials. The advantages to the proposed system would include easy decomposition, lesser health hazards and faster process that requires only an initial investment and is automatic.

A. Algorithm

Step 1: Start

Step 2: The system is switched on.

Step 3: The camera takes pictures of the objects to be identified.

Step 4: The images are analyzed with the trained data.

Step 5: The objects are then detected and localized by boundary algorithm.

Step 6: Object identification takes place.

Step 7: A prediction is made based on the identification and a probability index studied.

Step 8: The prediction with highest probability is regarded as the output.

Step 9: The object is then classified based on the output data as biodegradable or non-biodegradable.

Step 10: Stop

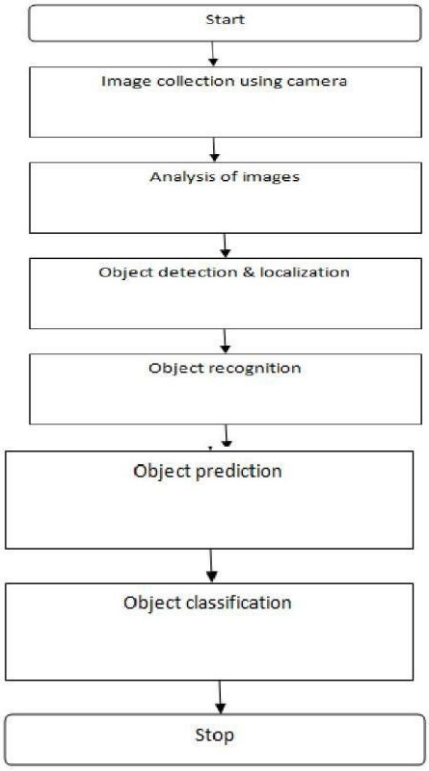


Fig 1. Flow chart

VII. WORKING WITH CAFFE

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A. Caffe Tutorial

The implementation part is done using Caffe which is a deep learning framework as software. Deep learning and deep features have only recently achieved strong results in many tasks. Thus, a common framework and shared models are needed to advance further research and applications.

The reasons for choosing this software includes its comparatively:

- High speed
- Open source
- Flexibility in all operating systems
- Reliable results
- Updated coding

Caffe software is interoperable and can be run on different operating systems as in Ubuntu, Windows and Mac. It provides a framework which can be modified for working with machine learning algorithms with a set of reference models. It has a library with C++, Matlab and Python through which the convolutional neural networks can be trained. It needs Cuda and Gpu along which it can process around 40 million images for various tasks such as detection and recognition. It has platforms that make developing and deploying of prototypes to cloud environment easy. It has also provisions for supporting research projects, applications in industry and various applications in speech, vision and multimedia through clear modules of code and bindings to Python and Matlab. Improvements in deep architectures have increased levels of performance of the networks. Convolutional neural networks have the capacity for back propagation through the convolutional layers. Caffe is an open framework for accessing the deep architectures. It has toolkit to train and deploy the networks along with examples. It also has provisions for fast implementation of the algorithms so that they can be deployed efficiently. Using it in CPU mode removes the need for special hardware after training the models. Predefined reference models remove the need for re-learning that may be costly and makes experimentation quick too. Caffe uses 4d array called blobs for storing the data. The layers in Caffe can take one or more input as blobs. The layers can perform backward or forward pass operations. Caffe trains the model with the layers in which the data layer retrieves the images from the disk. Caffe modifies the old model weights for developing a new task by initializing the new weights when needed. It can provide capacity for transferring the knowledge for object detection, retrieval and recognition. End to end training of network in Caffe can extract the required image features. In spite of many frameworks being available, the reason for choosing Caffe is that the architecture being used is that of a standard one and in order to train a million images or so, it is easier. Comparatively, Torch has more functionality and is also more flexible but it needs more coding and training, thus consumes more time.

Caffe is used with Level-Based database whose disk-key value store is chosen oven LMDB due to its interoperability to work in UNIX, Mac, Windows and Android. The input for this database is obtained from ImageNet which is managed by Stanford and Princeton University. It is an image database organized by hierarchy with each node having an average of 500 images. It can prove to be very useful in training a dataset provided a high processing computer is available to process these images.

VIII. IMPLEMENTATION

Training is the first step to be practiced after the collection of dataset. Training the dataset is very important to obtain accurate results. A large number of inputs have to be given to train the network for its own decisions.

Here for the purpose of recognizing images,

- Train a layer of features that receive input from the pixels of the image.
- The edges present in the image are recognized using Edge detection algorithm.
- Next, object parts are identified from various image processing algorithms such as feature extraction.
- Finally, objects are identified.

Though the training process is described above, before fine-tuning, a layer-by-layer pre-training is performed. Pre-training refers to the process where the user manually trains the data by describing the inputs. This is known as supervised training where the user supervises the results of inputs initially.

In the process of backtracking, the algorithm is made to process an image and provide an answer after which the user provides the actual answer and a comparison is made between the two and the algorithm „learns". Since there are many layers in deep learning, the output of one layer is fed as input to the next layer until all layers are pre-trained and ready for execution real-time.

To work in GPU mode in Caffe, Cuda is required. Opencv is installed to accelerate the GPU. BLAS performs the basic mathematical and algebraic operations. BOOST includes various libraries in C++ with pointers and few functions. The data structure of the new data layers are defined through the protobuf. Gflags and Glog helps in debugging of errors through commands. Imagenet database consists of a large collection of all possible images and so it is used as the source for training images. These images are stored in lmdb and leveldb of the software according to the requirement. For the layers, a lenet_train prototxt is created. The weights for the calculation are specified using lenet_solver prototxt. Thus the Caffe software is trained efficiently and easily.

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Deep Learning algorithm is implemented as the garbage images are identified to be that of biodegradable or not. The steps in the identification of images is similar to that in image processing and edge detection and matching method are used along with grayscale as well as gradient matching methods. Based on the outputs of these combinations of algorithms, the image is identified. In the Caffe software, once an object is identified, it is made to match with the other possibilities given during the training of data and a probability list is made for each possibility. The image that has the highest probability index is thus confirmed to be the object. The object from the garbage is thus identified and the robotic arm will be used to segregate the wastes accordingly in separate mounds. Since it

is a self learning algorithm, the system can learn and train by itself thus not requiring manual intervention.

IX. CONCLUSION AND RESULTS

Keeping our environment clean and eco friendly so that our next generation lives a disease free life is a priority. This project aims to support that thought. The Automatic waste management system is a step forward to the existing system to make the manual segregation of wastes easier. The developed system would pioneer the work for solid waste management process in the field of Artificial Intelligence. When properly trained, the system is highly efficient. The deep learning algorithm used here has better performance with comparatively less computation time. The emphasis of waste management policies in many countries around the world has transitioned from disposal to source segregation and recycling. The development of our project into a final product will help these countries in achieving their goal.

This project proposal for the management of wastes is efficient and time saving than the currently employed method where the municipality employees perform. Though this system is simple in concept, it is very valuable and affordable. Hence to ensure being automated, a system which takes lots of dataset as input without human intervention and also has the capacity to think by itself offers the best solution.

It acts as an aide for reducing pollution levels and in the long run focuses on the development of a nation and restoration of our ecosystem. We thus conclude that our project is an important asset to the society.

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