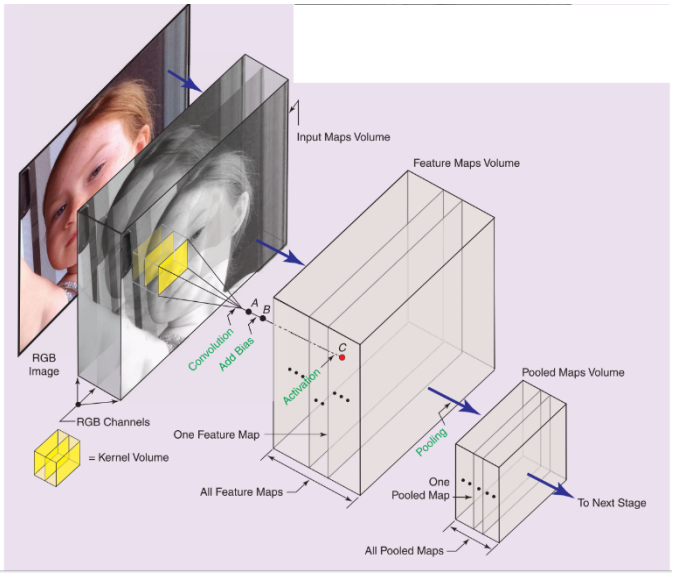

Fig. 1. Basic components of a DCNN stage [7]

The process of training a neural network is a problem of optimization; whose purpose is to adjust all parameters of the network when a misclassification is made so that the error in the output is minimized. This is done using gradient descent:

$$w_{ij}(l) = w_{ij}(l) - \propto \frac{\partial E}{\partial w_{ij}(l)} \quad (1)$$

$\propto$: learning rate
$w_{ij}(l)$: parameter or weight
l : neural network layer

This study sought to explore the possibility of DCNNs achieving high Precision in classifying the state of the waste container in an outdoor environment. To the best of our knowledge, there not studies that explores DCNNs for classifying if a waste container is full or not. Most studies touch the issue of segregating waste inside the container in classes such as paper, glass, metal, plastic, etc. [1][8][9]. DCNNs was used in [5] to identify waste container found in the outdoor. Other studies explored the possibility of determining the state of waste container using embedded systems equipped with ultrasonic and infrared sensors [3][4]. This is a desirable solution, however, this technology needs to be coupled to the waste container. This introduces flexibility, risk and cost issues and a high environmental impact [5] These were the closest studies to ours, but none of these studies have explored the possibility of DCNNs achieving high Precision in classifying the state of the waste container in the outdoor.

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III. METHODOLOGY

A. Building the dataset

The dataset was built from images captured from waste containers available at different location in some Mozambique cities. The dataset was initially composed by 65 images of waste container labeled as full and 75 labeled as not full. Since the size of the dataset was small and not enough to train the selected DCNNs, the following three augmentation techniques have been applied in order to avoid overfitting problem: blur, flip and random noise. The applied data augmentation technique made a slightly change on the images, so the augmented data did not differ too much to the original data, this can be seen at the Fig. 2. The final dataset is composed by 260 images of waste container labeled as full and 300 labeled as not full. All images in the dataset were automatically resized to 256x256 pixels.