# LPG Cylinder Delivery Authentication using Artificial Intelligence in Last Mile Delivery

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## Abstract

Last Mile Delivery (LMD) relates to all activities in delivering the product to the end customer in the supply chain. Safe, secure, and on-time delivery of products to customers are the primary objectives of businesses rendering LMD services. LPG cylinder distribution in India is one such business that provides LMD to its subscribed customers through delivery agents employed by distributors. Despite being an essential commodity, there is no system to confirm or authenticate the delivery. This absence of the system required for authentication causes a rise in black-market deviation, negatively affecting the distributor's reliability and customer satisfaction. To the best of our knowledge, there is no research towards developing an authentication system for delivery confirmation in LMD of LPG cylinders. Against this backdrop, this study proposes a secure, reliable, cost-effective Delivery Authentication System (DAS) using artificial intelligence and image metadata. The proposed DAS has an image classifier module built using Convolution Neural Network (CNN) and a metadata processing module to extract geolocation. A sample image dataset of an LPG cylinder and objects which looks similar to an LPG cylinder was used to train the image classifier. A prototype DAS with MobileNet V2 CNN architect is developed using Python and Keras library. With the data augmentation technique, we could train our CNN with a small dataset and prevent it from underfitting. The transfer learning technique helped our CNN to generalize well on the study data without overfitting and produced an accuracy score of 97%. The expected outcome of this study is to reduce black-market deviation cases and to improve the distributor's reliability as well as the customer satisfaction.

**Keywords**
LPG cylinder, Last Mile Delivery, Delivery Authentication System, Artificial Intelligence.

## 1. Introduction

Essential commodities are those whose supply, if disrupted, would negatively affect the harmony in society. In India, such products are protected under the Essential Commodities Act. Liquified Petroleum Gas (LPG) cylinders or cooking gas cylinders is one of the essential commodities in India. These LPG cylinders are delivered to customers by delivery agents employed by distributors selected by petroleum companies. In India, Indian Oil Corporation (IOCL), Bharat Petroleum Corporation Limited (BPCL), and Hindustan Petroleum Corporation Limited (HPCL) are the major stakeholders in LPG cylinder distribution. When a customer orders, the distributor assigns the job to the deliveryman rendering service to the customer's residential area. The delivery man delivers the cylinder to the customer's doorstep, collects the empty cylinder and payment, and provides the customer with a cash memo (order bill).

The cash memo has two sections, one for an office copy, where the customer or the receiver on behalf of the customer must attest, and a customer copy. After receiving the attestation from the customer, the deliveryman proceeds to the next delivery. It is to be noted that the distributor or the petroleum company does not authenticate the attestation provided by the receiver in any instance and is only a formality. Also, the customers attesting the office copy of the cash memo do not always attest properly. This naïve current practice has paved the path for the increase in case of black-market deviations, where the deliveryman will sell the cylinder in the black market. In this situation, the customer will wait for his order to be delivered, and the distributor cannot track the order status. This increases customer complaints regarding delivery delays, negatively affecting the distributor's reliability and causes inventory accounting problems for the distributors. The black-market deviation is a significant threat to businesses involved in LMD. With this background it is evident that a fast, secure, reliable, and cost-effective Delivery Authentication System (DAS) ensures the customers have received their orders and the distributors have an account for the number of cylinders outbound from the warehouse and the number of cylinders delivered. In this study one such DAS is developed using artificial intelligence and image meta-data.

The paper is organized as follows. Section 2 presents the characteristic features of the proposed DAS. Section 3 presents the literature review. Section 4 introduces the research methodology for developing the proposed DAS. Section 5 presents the computational results and analysis. Finally, Section 6 concludes and provides similar areas of application.

## 2. Required Characteristics of the Proposed DAS

Based on studying the current practice on LMD of LPG cylinders, the following essential characteristics are considered for the proposed DAS:
a)As the labour force employed for delivery service are unskilled, the proposed DAS should be a simple, user-friendly one, and requiring no special skills.
b)The delivery involves carrying the cylinders to the customer's location. The proposed DAS must not include carrying special pieces of equipment for delivery authentication.
c)The proposed DAS must not be a workload or burden to the customers.

## 3. Closely Related Literature Review on Authentication and Image Classifiers

To the best of our knowledge there is no specific study reported in the literature for delivery authentication in the LMD of LPG cylinders. However, we will be reviewing the authentication process in general and the technological advancement in the authentication process. Velasquez et al. (2018) describe authentication as the first defence against a security threat. Authentication is the process of positively verifying a user's identity to allow them access to resources. They concluded that though extensive research has been done on authentication system, their practical usage has yet to be researched much. Barkadehi et al. (2018) provide different types of authentication systems and associated security threats with advanced technology. They concluded that authentication is complex and that using the latest technologies, like biometric authentication, artificial intelligence, etc., has the potential to make a sound authentication system. Papathanasaki et al. (2022) describe multi-factor authentication as one of the most secure ways of authentication.

MacRae et al. (2016) explored the usability and security of geographic authentication schemes. Their study states that geographic authentication is more secure than traditional text passwords but requires more memory storage capacity for its usability. They concluded that future geographic authentication activities must focus on harnessing memorability and enhancing security. Shin et al. (2015) proposed a map-based security authentication to replace traditional text-based passwords. They concluded that their proposed method was secure, and the users appreciated the new authentication approach. Aldina et al. (2021) state that geolocation-based authentication is widely used in banking systems. They concluded that user authentication systems are only partially secure and can be broken. Pathak and Singhal (2023) proposed a machine-learning model to detect fraudulent transactions based on customers' geolocation. They concluded that Artificial Intelligence provides many models to build efficient models for security and authentication applications.

Zhang and Lu (2021) described that computer vision enables computers to recognize and understand the world like humans. Computer Vision is widely used for facial recognition and image recognition and classification. Chen et al. (2021) reviewed image classification based on Convolution Neural Networks (CNN) and various neural network architectures. They proposed the MobileNet network as a good fit for mobile and embedded devices. Li et al. (2022) highlighted Adam Optimizer and Rectified Linear Unit (ReLU) Activation functions to work well on many practical problems. They described Adam Optimizer and ReLU activation functions as a go-to option when the developer has no choice.

Gupta et al. (2022) describes various learning techniques which help the network extract features from the images without involving the user. Among these, the transfer learning technique is the most reliable and has provided accurate results relative to others. Ogundokun et al. (2022) used the MobileNet to classify breast cancer scans. They concluded that better accuracy and overfitting issues can be addressed using a balanced dataset, optimizers, and more training epochs. Shukla et al. (2023) used MobileNet with transfer learning to recognize masked faces during the COVID-19 pandemic. They concluded that the MobileNet V2 architect achieved better results than other architects. Based on the analysis of various authentication and image classifier related studies, to the best of our knowledge, no research contribution was made to DAS for the LMD of the LPG cylinder.

## 4. Research Methodology for Developing the Proposed DAS for LMD

The proposed DAS has two modules – an image classifier module and an image metadata processing module. CNN is a subsection in artificial intelligence, generally used to build models for object detection and image classification. Image classification is a supervised learning technique where the model gains knowledge about the input image and will assign its respective category label. By training on large data, the model gains a generalized understanding of the training data categories. This knowledge gained by the image classifier will be used to predict which category an input image belongs to. The core building block of a CNN is known as a convolutional layer, and the sequential order in which these layers are linked is known as neural network architecture. Many research contributions were made toward developing various neural network architectures whose accuracy was recorded by training on standard datasets like CIFAR-10, ImageNet, MS-COCO, MNIST, etc. This knowledge gained by training from standard datasets is referred to as weights. These weights can be reused to train on custom dataset using the transfer learning technique.

The input images are of dimensions: *Width x Height x Depth*, where the value of depth is 3 [and 1 for colour, 2 for black, and 3 white images]. The colour images have three layers Red, Green and Blue (RGB) where each pixel value in each layer ranges from 0 (for black) to 255 (for RGB colour). To minimize the computational cost, the pixels in the image are scaled to be between 0 and 1 by dividing each pixel by 255. Images of similar pixel dimensions for each category are provided as input data to train an image classifier. Equal representation of data from each category is mandatory to prevent the image classifier from being biased toward a particular category. It must be provided with a large amount of data to prevent the image classifier from underfitting. The burden of data collection to train an image classifier is surpassed using the data augmentation technique. By data augmentation technique, a single data will be represented in different forms and angles by which better accuracy results can be achieved using a small-size dataset.

The detailed description of the dataset used to train the image classifier module and the image classifier developed for the proposed DAS is discussed in the following subsections.

### 4.1 Training Dataset for the Image Classifier

The dataset used for our study will comprise images of LPG cylinders and other objects which look like LPG cylinders. Our study uses soft drink can, bottled water can, and fire extinguisher, which has similarity in appearance to an LPG cylinder. This will enable our model to extract features of LPG cylinders along with gaining knowledge to differentiate other similar-looking objects from LPG. The dataset is balanced with 50 data from each category. Each input image is resized to dimensions: *150 x 150 x 3*, and the pixels in the image are scaled to minimize computational cost. A sample of the dataset and augmented data are shown in Figure 1.

(a) (b)

Figure 1. (a) Sample Images considered in the Training Dataset; (b) Augmented Data Sample.

### 4.2 Image Classifier Model

The proposed DAS's image classifier module is built using MobileNet V2 neural network architecture and is trained by transfer learning technique using the weights from the "ImageNet" dataset. We have subjected the model to a learning decay rate to prevent the model from overfitting. The model is trained with the parameters: (i) Optimizer – Adam; (ii) Activation Function – ReLU, Softmax; (iii) Input Image size – 150x150 pixel; (iv) Epoch – 20; (v) Learning Rate – 0.01; (vi) Loss Function – Categorical Cross Entropy; and (vii) Evaluation Metrics – Accuracy. The model and DAS were developed using Keras library, Python on a system with an i7 8th gen processor and 16GB RAM. The model summary is graphically represented in Figure 2.

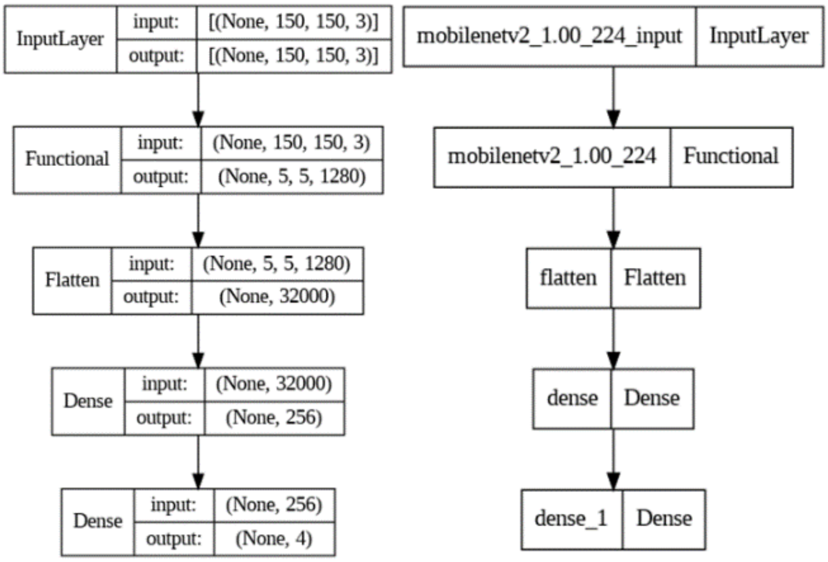



Figure 2. Image Classifier Model Summary

### 4.3 Operational Procedure of the Proposed DAS

The operational procedure for the proposed DAS is developed under the following assumptions:

i. Delivery agents have a smartphone while rendering services without signal hindrance.
ii. The customer's delivery locations are geocoded.

The proposed DAS will function as follows:

i. After delivering the cylinder at the customer's location, the delivery agent will click a picture of the delivered cylinder and input the customer's consumer number.
ii. The proposed DAS will receive the captured image and the consumer number as input.
iii. The image classifier module will recognize whether the captured image is an LPG cylinder.
iv. If the image is an LPG cylinder, the proposed DAS will extract the geolocation information from the image.
v. Using the Euclidean function, the proposed DAS will measure the distance between the geolocation extracted from the image and the customer's geolocation from the database.
vi. If the distance is less than 20 meters, the proposed DAS authenticates the delivery and registers the delivery confirmation along with the delivery date and time.
vii. At the end of the day, the distributor will have a list of orders delivered and the total number of cylinders outbound from the warehouse.

## 5. Computational Results

The dataset is divided into training (30), validation (10), and testing (10). The validation dataset is used to fine-tune the hyperparameters of the model, and the testing dataset is used to evaluate the model's performance finally. The number of times the model trains on the dataset is referred to as the epoch. The model's loss and accuracy computed for the training and validation data for each epoch are graphically represented in Figure 3.

The model has scored 97% of f1-score accuracy on the testing dataset, stating that the model has attained a perfect trade-off between precision and recall. The model's performance metrics are tabulated in Table 1. The confusion matrix in Figure 4 shows that the model has never misinterpreted LPG cylinders with other similar-looking objects (that is, this depicts that the model has generalized well on the input dataset).

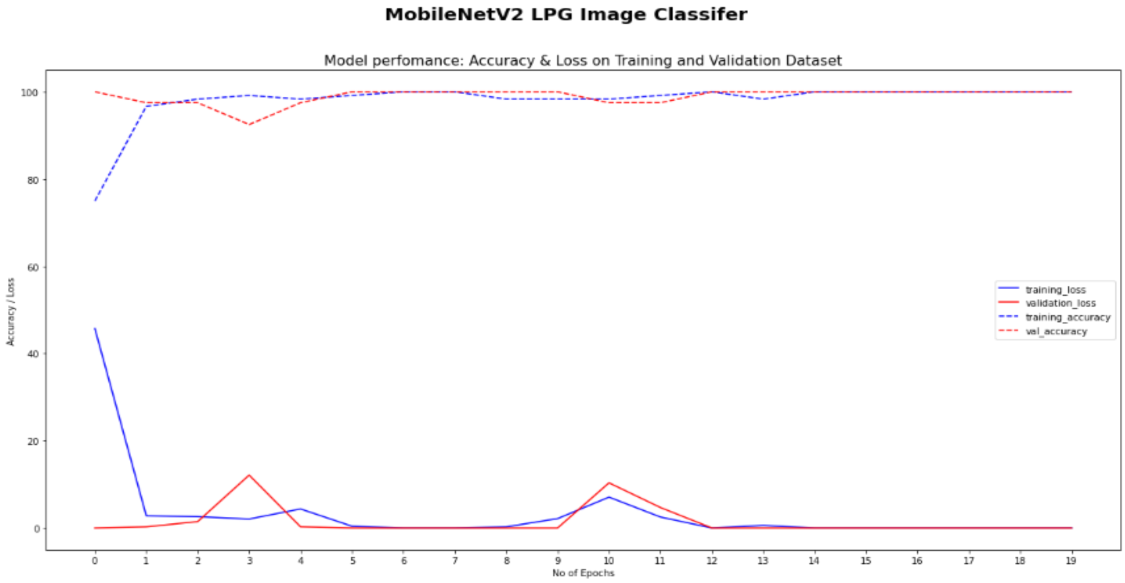



Figure 3. MobileNetV2 LPG Image Classifier Model Performance

Table 1. LPG Image Classifier Model Performance Report

| | Precision | Recall | f1-score | Support |
|---|---|---|---|---|
| Drinks Can (CCAN) | 1 | 1 | 1 | 10 |
| Extinguisher (FEXT) | 1 | 0.9 | 0.95 | 10 |
| LPG Cylinder (LPG) | 1 | 1 | 1 | 10 |
| Water Can (WCAN) | 0.91 | 1 | 0.95 | 10 |
| Accuracy | | | 0.97 | 40 |
| Macro Avg | 0.98 | 0.98 | 0.97 | 40 |
| Weighted Avg | 0.98 | 0.98 | 0.97 | 40 |

With satisfactory results from the model, the prototype DAS was developed to function as described earlier in Section 4.3. The LPG cylinder image was clicked at the customer's location with Consumer Number 0. The proposed DAS has confirmed delivery within a second

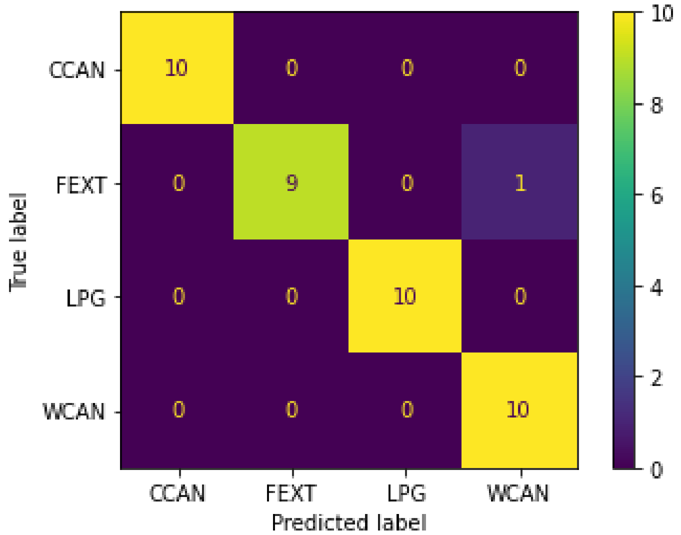
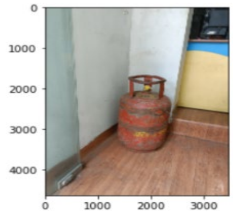



Figure 4. Confusion Matrix of LPG Image Classifier Model Performance

. Further, the prototype DAS was subjected to the following 3 real-time cases, and the results from the programming environment are shown in Figure 5 to Figure 7 below.

***Case 1:*** The image is an LPG cylinder delivered at the correct location.

```
plt.imshow(img.imread(lpg_image_path))
plt.show()
```



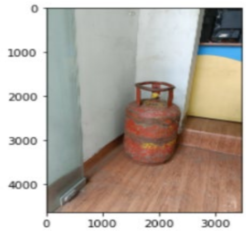

```
LPG_DSA_System(lpg_image_path,model_path,model_pickle_path)
```

```
Enter the Consumer No: 0
1/1 [==============================] - 1s 1s/step
Delivery Completed
LPG Cylinder delivered on 2023:07:11 at 11:52:37
```

Figure 5. LPG Image and Delivered at Correct Location

***Case 2:*** The image is an LPG cylinder delivered at the wrong location.

```
plt.imshow(img.imread(lpg_image_path))
plt.show()
```



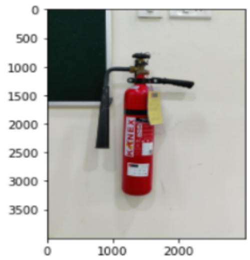

```
LPG_DSA_System(lpg_image_path,model_path,model_pickle_path)
```

```
Enter the Consumer No: 1240
1/1 [==============================] - 1s 969ms/step
Wrong Delivery Location
```

Figure 6. LPG Image and Incorrect Delivery Location

***Case 3:*** The image provided is not an LPG cylinder.

```
plt.imshow(img.imread(other_image_path))
plt.show()
```




```
LPG_DSA_System(other_image_path,model_path,model_pickle_path)
```

```
Enter the Consumer No: 1240
1/1 [==============================] - 1s 752ms/step
Not LPG Cylinder
```

Figure 7. Not LPG Image

## 6. Conclusion

This study addresses the issue of black-market deviation in the LMD of LPG cylinders in India by proposing a prototype DAS. The proposed DAS is developed using Artificial Intelligence and Image Metadata. The Image Classifier model was developed using the transfer learning technique with MobileNetV2 neural network architecture. The data augmentation technique has enabled to train the proposed model even with a small dataset. The model's accuracy, f1-score, and confusion matrix indicated that the model has generalized well. One of the very important research components: "comparative analysis of delivery authentication system (DAS) and geographic authentication system (GAS) in terms of both storage and computational memory utilization," is yet to be analyzed and is under progress of the research agenda towards the thesis/dissertation work of the first author of this paper.

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