Ayurvedic system of healthcare has gained importance and is becoming popular. It is a comprehensive system of healthcare that originated in India. Because of the effectiveness and less adverse reactions compared to the synthetic chemicals, the Ayurvedic system has attained popularity globally. The classical text of Ayurveda mentions a number of plants for the management of several diseases. Several researchers had given their contributions for finding hidden therapeutic potentials of a number of ayurvedic drugs, but still, a number of plants need a comprehensive study on them. Therefore the present study is focused on such a very effective and potent medicinal herb- Liquorice, Rhubarb and Datura. In this chapter explain the details of the herbal plant consider for the powder microscopic image based classification. Also, discuss the procedure for the preparation of the powder slide of herbal plants for the microscopic image acquisition. Herbal plant details are explained in the next section.

### 3.1 Details of herbal plant

The present dataset consists of three herbal plants namely Liquorice, Rhubarb and Datura. Details of the plants are discussed in this section.
3.1.1 Liquorice

The Scientific name of the Liquorice is *Glycyrrhiza glabra*. The word *Glycyrrhiza* is defined by the Greek word *glykos* (stands for sweet) and *rhiza* (stands for root). *Glycyrrhiza glabra* Linn, commonly known as *liquorice* and *sweet wood* belongs to the Leguminosae family. Vernacular names for Liquorice are *Jeshthamadh* (Marathi), *Jothi-madh* (Hindi), *Yashtimadhu, Madhuka* (Sanskrit), *Jashtimadhu, Jaishbomodhu* (Bengali), *Yashtimadhukam* (Telugu), *Jethimadhu* (Gujarati) and *Atimadhuram* (Tamil). Liquorice is native to various parts of Asia such as India and Southern Europe. It is one of the widely used medicinal herb from the medical history of Ayurveda. It is also used as a flavouring herb. It is assigned as one of the good medicine for relieving pain and other factors such as discomfort caused in the stomach. The study of this herbal plant is to compile its traditional uses, bioactive constituents, and pharmacologic activities. This may be useful in finding positive effects on the healthcare industry.

It is effectively used in acidity, bleeding, jaundice, hoarse-ness, bronchitis, diarrhea, and for certain types of fever. Liquorice becomes a vital component in medicinal oils needed for the treatment of haemorrhagic diseases, epilepsy, and paralysis.

The diagnostic characters of Liquorice are:

(a) The very abundant fibres which occur in groups surrounded by a calcium oxalate prism sheath. Individual fibres are very thick-walled with few, small pits; the different layers in the walls are sometimes clearly seen and only the middle lamella and primary wall give a reaction for lignin; frequently no lumen is visible.

(b) The prisms of calcium oxalate, the majority of which are fairly uniform in size and occur in the cells forming the crystal sheath surrounding the fibres. In addition a few larger prisms occur; they are present in some of the parenchymatous cells of the medullary rays and pith and may be found in these cells or, more usually, scattered in the powder.
3.1.2 Rhubarb

The scientific name of the Rhubarb is *Rheum rhabarbarum*. Rhubarb is considered one of the former and most commonly used herbal medicines in some countries including Asia. For the treatment of constipation, cancer, and inflammation, it is used as herbal medicine. Rhubarb roots have been used as a laxative in traditional Chinese medicine for many centuries. Rhubarb contains protein and carbohydrate which are the main sources of energy for the human body. Like Rhubarb, there are various plants exist which have similar properties. So it is necessary to have knowledge of its original proportion in any medicinal products, which will help in calculating side-effects.

The diagnostic character of Rhubarb is the fairly abundant cluster crystals of calcium oxalate which are found scattered and in some of the parenchymatous cells. They are very large and are frequently fragmented.

3.1.3 Dhatura

The scientific name of the Dhatura is *Dhatura stramonium* and commonly found throughout India. In Indian sub-continent pre-historic use of Dhatura in medicinal and ceremonial rituals could be observed. In Ayurveda, its seeds, roots and dried whole plant are used for medicinal purpose. About ten species of Dhatura are found. An extract made from the leaves is taken orally for the treatment of asthma and sinus infections, and stripped bark is applied externally to treat swellings, burns, and ulcers. The incidence of poisoning is sporadic with a cluster of poisoning cases in the 1990s and 2000s, the United States media reported some cases occurring mostly among adolescents and young adults dying or becoming seriously ill from ingesting. So, in any case, Dhatura is taken in medicine production only after doing purification.

The leaves, seeds, and root of the plants are used in anti-catarhal, febrifuge, anti-diarrhoeal, anti-dermatosis. They are used in fever with congestion, insanity, diarrhea, and skin diseases. A diagnostic character of Dhatura is the glandular trichome, which has very large and shape is similar to trapezoidal.
3.2 Preparing the sample slide

In the microscopical examination of herbal plants, the most diagnostic features are specific cell types and calcium oxalate crystals, and they are best observed in a Chloral Hydrate mount. However, before the details can be discerned it is essential to 'clear' the preparation in order to allow the chloral hydrate solution to penetrate the tissues and remove entrapped air bubbles. The procedure for preparing a microscopic sample slide of herbal powder is as follows.

In the test tube add the 5 ml chloral hydrate solution to the 50 mg herbal powder. Then heat very gently approximately 50 to 70 °C by passing the test tube to and fro over a very low flame of a burner. As soon as bubbles start appear to stop the heating. It is important to ensure that sufficient liquid is always present to prevent the preparation of drying out. When a satisfactory preparation has been made, take the few drops of solution on the slide and add one or two drops of a solution of glycerol to inhibit the formation of crystals of chloral hydrate during the subsequent examination of the slide and then apply a cover glass. The clearing process removes starch granules and all water-soluble cell inclusions.

3.3 Image Acquisition

The microscopy images were obtained using a Lawrence & Mayo microscope coupled with a 3.0 Mega Pixel CCD camera. After preparing the sample slide of herbal powder, observe the sample under a digital microscope with the different objective of 4x, 10x and 40x. Total magnification of the sample in the range of 4x to 100x possible using the digital microscope of Lawrence and Mayo and 3.0 Megapixel CCD camera. Then select the proper objective and proper focus in the microscope for proper display of the image. After that capture, the image using capture software and save the image to the computer. Figure 3.1 shows the block diagram of image acquisition. Figure 3.2 shows the experimental setup for the image acquisition. In this setup, Lawrence & Mayo microscope is used.
The CCD camera is connected to the laptop for digital image acquisition. The powder of three herbal plants Liquorice, Rhubarb, and Dhatura are collected from the pharmacy lab of the Nirma University. The microscopic image is digitized with a 3.0 megapixel CCD camera with Lawrence & Mayo microscope with different magnification at 4x, 10x, and 40x. Figure 3.3, Figure 3.4 and Figure 3.5 shows the microscopic images of Liquorice, Rhubarb and Dhatura at 4x, 10x and 40x resolution. The cell shape of the herbal plants highlighted in the above figures. The cell shape and structure of the powder microscopic images of herbal plants are relatively different from one another. These features facilitate cell-based automatic detection of herbal plants.

Figure 3.1 Block Diagram for microscopic image acquisition
Figure 3.2 Experiment setup for image capturing

Figure 3.3 Microscopic Images of Liquorice with highlighted fibres in the red box, (a) top row: 4x resolution, (b) middle row: 10x resolution and (c) bottom row: 40x resolution
Figure 3.4 Microscopic Images of Rhubarb with highlighted rosettes of calcium oxalate in the red circle, (a) top row: 4x resolution, (b) middle row: 10x resolution and (c) bottom row: 40x resolution.

Figure 3.5 Microscopic Images of Dhatura with highlighted trichomes in the red box, (a) top row: 4x resolution, (b) middle row: 10x resolution and (c) bottom row: 40x resolution.
Figure 3.6 shows the microscopic image of Liquorice, Rhubarb, and Dhatura at a different resolution. There are many microscopical characters such as cork in surface view, transversely cut cork, group of tracheids showing bordered pits, starch grains, tangentially cut medullary ray cells with associated parenchyma, a fragment of vessel with elongated bordered pits, crystal fibres and prismatic crystals of calcium oxalate for the identification of Liquorice plant. But Liquorice plant is uniquely identified by microscopic characters of the crystal fibre cell which is always found in the microscopic image. Similarly, Rhubarb and Dhatura plant are uniquely represented by microscopic characters of rosette crystals of calcium oxalate and nonglandular trichomes respectively. The shape of the crystal fibre cell of Liquorice is visible at 4x and 10x magnification while the structure is clearly visible at 40x magnification in the microscope. The microscopic character of the Rhubarb and
Dhatura is clearly visible only at 40x magnification in the microscope. The powder microscopic images of Liquorice at 10x magnification and Rhubarb and Dhatura at 40x magnification are considered for the classification using the shape and texture based features. A total number of powder microscopic images per herbal plant is listed in Table 3.1.

<table>
<thead>
<tr>
<th>Herbal Plant</th>
<th>4x</th>
<th>10x</th>
<th>40x</th>
<th>Total Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquorice</td>
<td>324</td>
<td>322</td>
<td>280</td>
<td>926</td>
</tr>
<tr>
<td>Rhubarb</td>
<td>258</td>
<td>360</td>
<td>260</td>
<td>878</td>
</tr>
<tr>
<td>Dhatura</td>
<td>100</td>
<td>200</td>
<td>390</td>
<td>690</td>
</tr>
</tbody>
</table>

### 3.4 Challenges in herbal plant classification

The herbal plant can be classified based on the leaf, root or any parts of the plant or whole plant. The shape, colour and structure of the leaf of the plant are used for the classification of the plant based on the leaf. Powder of the herbal plant prepares from the dried roots or leaves. Colour and odour of the powder can be used to classify the plant from the powder. Due to a large collection of herbal plant, it is very difficult to classify the plant from the powder. Microscopic examination of powder can be useful for the classification of the herbal plant. An identification of powder of herbal plants can be performed by the presence or absence of different cell type based on their histological characters, e.g. fibres, stone cells, vessels, trichomes. Figure 3.3, Figure 3.4 and Figure 3.5 show the histological character of microscopic images of powder herbal plant of Liquorice, Rhubarb and Dhatura at 4x, 10x and 40x resolution. From these figures, concluded that there is a difference in the shape and size of the histological character of each herbal plant. But there is a large variation in the shape of the histological characters in the same herbal plant. This is very challenging for the classification of the plant based on the histological characters. So, we have to select the features for the recognition of the plant which is invariant to rotation, scale and shift of the histological character of the herbal plant. So, we have considered the
shape and texture based invariant features for the classification of the herbal plant. Deep convolutional neural networks (CNNs) have become one of the state-of-the-art methods for image classification in various domains (Nguyen et al. 2018; Tajbakhsh et al. 2016). Limited training images are available for herbal plant image classification from its powder form so transfer learning using CNNs is often applied to improve classification. In these techniques, image features can be extracted automatically from image datasets and these features can be utilized for classification. We have also used the deep learning features for the microscopic image classification to reduce the problem of variation of the histological character of the herbal plant.