CHAPTER 3
PROBLEM FORMULATION AND OBJECTIVES

3.1 PROBLEM BACKGROUND AND MOTIVATION

Shape is an important and necessary feature for description of image boundary and image content (Shekar and Pilar, 2014). Shape and topological analysis of image pattern is of extreme importance in image processing and computer vision (Nemeth et al., 2011). Thinning is an important technique for representing the shape of a pattern with limited number of object points (Chatbri et al., 2016). Therefore, thinning of digital images is widely used for shape description in the field of image processing as thinning simplifies the process of object representation, extraction of representative features and topological analysis of image pattern. A thinning process transforms an input image to arcs and curves of unitary thickness. Numerous thinning algorithms and techniques have been proposed over decades. In general, a particular thinning technique may focus on some fundamental topological and geometrical requirements while compromising the other.

Different performance parameters are used for evaluation of thinning algorithms. The thinning algorithms may be evaluated based on results obtained for particular type of datasets. Alternatively, thinning algorithm evaluation may be parameter specific in terms of performance.

Algorithm presented in (Zhang & Suen, 1984) is fast and generate connected skeleton. This algorithm is based on two sub iterations and is base for different algorithms by various researchers till date. However some triangles are generated in thinned image resulting in skeletons that are not unit pixel wide.

Algorithm presented in (Huang et al., 2003) is based on pixel elimination templates. Further, issue of two pixel wide lines is addressed. In order to overcome loss of information, preservation templates are used. Adaptive thinning framework using gaussian filters is proposed in (Chatbri and Kameyama, 2012). The proposed gaussian
filter based thinning framework is used in Chatbri and Kameyama (2014). The algorithm shows improvement in results for noisy sketch images.

From the survey of different thinning algorithms, it is inferred that thinning algorithms require three major tasks to be implemented:

1. Removing the unwanted thick pixels
2. Number of sub-iterations, and
3. Stopping the thinning process when the skeletons are very close to unit pixel width.

The first task can be done easily by deleting the contour pixels based on pixel deletion criteria of traditional thinning method. One such criterion for pixel deletion uses color coding for different types of pixels (Ali, 2012). Further, many thinning algorithms (Zhang and Suen, 1984; Kundu et al., 1991; Datta et al., 1994; Jagna et al., 2010) involve multiple sub-iterations. Applying neural network can reduce multiple sub-iterations to single one. The main problem arises in the third part, because the stopping decision has to be done automatically. This can be accomplished by training a neural network.

The survey of research in the field of thinning, performance parameters and inferred facts motivate the possibility of designing and training a neural network for traditional iterative thinning algorithms to produce quality skeletons reducing multiple sub-iterations to single one and meeting the stopping criteria automatically. However, there is a possibility of applying other neural network models in order to further develop a thinning algorithm.

As described by Egmont-Petersen et al. (2002), the preprocessing operations in recognition problems involve three types of problems namely optimization, approximation and mapping to which artificial neural networks can be applied. Hopfield networks may be applied for optimization problems. For problems related to approximation, Feed forward ANNs can be applied. In mapping problems, ANNs are trained to perform tasks based on pixel neighborhood. Trained neural networks are applied to images for different purposes like enhancement, restoration and other related operations. The thinning is an important preprocessing stage in recognition process. As
discussed in section 1.5 of Chapter 1, in conventional thinning, the mapping of pixels is done based on 8-neighbors of a pixel and hence possibility of training a mapping neural network can be explored.

Present work proposes a thinning framework based on training of mapping network based on conventional pixel deletion conditions to perform thinning of handwritten devnagri numerals using a trained ENN. An ENN is trained for offline handwritten devnagri numerals to improve the results of existing conventional thinning algorithm. The training rules are formed based on pixel deletion criteria using 8-pixel neighborhood. The trained neural network is applied to devnagri numerals for thinning.

3.2 SELECTION CRITERIA FOR DATASET

Since the beginning of 1980 there has been remarkable increase in the research in the field of handwritten numeral pattern recognition. Some of the challenging issues arising in handwritten devnagri numeral recognition are:

1. Different writing styles and infinite variations in handwriting of individual writers (Amin and Wilson, 1993).
2. Different shapes of handwritten devnagri numerals, and
3. Noise existing in the numeral image patterns.

From the Table 2.1 of Literature survey, it is observed that very few researchers have emphasized and addressed about thinning algorithms for devnagri numeral script. Further, devnagri script is used in many official Indian languages like Hindi, Sanskrit, Nepali, Marathi, Sindhi and Konkani. Many other Indian languages like Punjabi use scripts similar to Devnagri. More than three hundred million people use Devnagri script for documentation (Jayadevan et al., 2011). Four numerals in Devnagri script have almost same structure and visual appearance as in Bangla script (Obaidullah et al., 2015). Therefore, processing of devnagri script in Hand Written Character Recognition system is an active area of research. Scope of present work includes offline hand written devnagri numerals.
3.3 PROBLEM STATEMENT

Based on problem background for present study described in section 3.1 and subsequent selection criteria for dataset, the problem statement is described as: “Algorithm Design for Offline Handwritten Devnagri Numerals using Neural Network”.

3.4 OBJECTIVES

The objectives of present work are:

1. To review and compare some existing thinning algorithms based on geometrical and topological parameters. The parameters chosen are connectivity, unit pixel width and compression ratio.
2. To propose a framework for a neural network based thinning algorithm.
3. To evaluate the performance of the proposed thinning algorithm in comparison to reviewed algorithms.

3.5 WORK FLOW

The flow of control for present work consists of following sequence of steps:

1. Identification of problem.
2. Creation of hand-written Devanagari numerals dataset.
3. Implementation and performance analysis of three thinning algorithms.
5. Performance evaluation and comparison of proposed neural based thinning approach.

These steps are shown in Figure 3.1.

3.5.1 Identification of Problem

Problem identification is starting and foremost step for carrying out any research work. A problem should be clearly understood. In order to identify the present problem, broad
introduction of image processing and pattern recognition domain to which the problem belongs is provided in Chapter 1.

**Figure 3.1 Flow of Control for Present Work**

Shape representation and feature extraction have significant importance in pattern recognition. The main purpose of shape representation is to encode a shape such that features of the shape can be extracted easily. One such representation technique is thinning in which an object or pattern is reduced to minimum size necessary for machine
recognition. Thinning process facilitates easy extraction of features, pattern analysis and object representation. The problem for present work is identified and refined by referring papers from different journals and conferences. A thorough survey was done in the related domain as described in Chapter 2. The details regarding problem formulation have already been provided in section 3.1.

3.5.2 Creation of Hand Written Devanagari Numeral Dataset

Devnagri is used in many official languages for documentation in India. A set of devnagri numerals is shown in Figure 3.2.

<table>
<thead>
<tr>
<th>Number</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devnagri</td>
<td>०</td>
<td>१</td>
<td>२</td>
<td>३</td>
<td>४</td>
<td>५</td>
<td>६</td>
<td>७</td>
<td>८</td>
<td>९</td>
</tr>
</tbody>
</table>

Figure 3.2 An Offline Hand Written Devnagri Numeral Dataset

Due to different issues involved in Hand written scripts i.e. different writing styles by different persons, variability in writing by same person at different times, samples of devnagri numerals from different users are taken.

In present work, samples from five different users are taken. The complete dataset consist of fifty input images. Before using the created numeral images, resizing is done as a preliminary step. In present work, the numeral images are resized to 64x99. However, there is no specific criterion for resizing of images. The size is chosen based on convenience and preservation of aspect ratio. Dataset consisting of ready to use fifty images is shown in Appendix B. The images are stored in BMP format.
3.5.3 Implementation and Performance Analysis of Thinning Algorithms

From the literature survey, three algorithms are identified for implementation. The purpose is to have practical exposure regarding pixel deletion criteria for generating thinned images. The details of thinning algorithms, performance parameters and analysis are discussed in Chapter 4.

3.5.4 Proposing a Thinning Approach based on Neural Network

Based on literature survey and analysis of implemented thinning algorithms, a neural approach based on conventional pixel deletion criteria and unit pixel width conditions is proposed. The Elman neural network is trained for this purpose. The details of proposed methodology and experimental design are presented in Chapter 5.

3.5.5 Performance Evaluation and Comparison of Proposed Neural based Thinning Approach

The performance of proposed neural based thinned approach is evaluated and compared with already implemented thinning algorithms using parameters described in Chapter 4. The details of performance evaluation and comparison are given in Chapter 6.

3.6 SCOPE

The scope of present work is given below:

1. The main focus is on pre-processing stage of a recognition system. The purpose is to ease the process of feature extraction and recognition by transforming an input devnagri numeral to that of unit pixel width.
2. The dataset used is hand written devnagri numerals taken from five different users.
3. Three thinning algorithms are implemented and evaluated to understand the pixel deletion criteria used for thinning.
4. A neural approach based on conventional thinning algorithm is developed. For this purpose, an ENN is trained in supervised manner using GDX back propagation training algorithm. The trained ENN is used for thinning of devnagri numeral dataset.

5. Performance parameters used are compression ratio, pixel removal parameter, connectivity, triangle count, unit pixel width, and information loss and topology preservation parameter.

3.7 SUMMARY

In present chapter the problem background is reviewed. The problem identification, formulation and motivation behind the problem are discussed. The selection criterion for dataset of hand written devnagri numerals is described. The problem statement and objectives are listed. Work flow for present work is also explained.