Chapter 1

INTRODUCTION

Objective

To introduce the research topic "Prediction of Future Appearances of Child's Face Images",

What will a child look like after a number of years? Prediction of older face images of a child has many practical applications such as searching for missing children, face recognition in different ages, and automatic photograph updating in photo ID document *etc*. In most of the countries in the world, there are so many children who are reported missing each year owing to various reasons. As per the Information of Home Ministry of India, 32,500 thousand children were missing during 2011 to 2014 [76], and in an average of 100 thousand children are missing in every year. Again 797,500 children were missing according to the research of NISMART-2 (Second National Incidence Studies of Missing, Abducted, Runaway, and Thrownaway) [60] in USA in the year of 1999. These children were lost when they were at the age of 18 years or less. If a missing child is not found early, then due to the changes in face it is very difficult to find him/her in older ages. So if we can predict older face images then it would be very helpful to the society for successful search of a missing child. Also, the technique of reverse aging synthesis

may be helpful in some situations like locating an elderly person who went missing because of memory loss.

The natural process of aging changes the shape and texture like wrinkles in the appearances of human faces. Gender and ethnicity also take important role in appearance variation. Some controllable factors are social behaviours including life style, stress, climatic conditions *etc.* Predicting facial appearance becomes difficult because of several conditions of images such as illumination variances, facial expressions, and head pose, hair style, eye-glasses *etc.* Other variances can appear because of facial hair and items such as hats and sunglasses.

Age-progression is the way of modifying the appearance of face image of a person from child to adult. This is a task of face synthesis as opposed to face analysis tasks where recognition is performed based on facial attributes. In earlier, experts like forensic artists produced the older face images of a given child's image. The artists used some older face images of the family members of the input child to draw the sketch of such aged images. The output images produced by the professional artist are not unique, because the outputs are totally dependable upon the way of thinking of the artists. Also it is very must cost effective and time consuming, and for which it can no be usable for any general purposes. Therefore, automated age progression methods are reported to perform better than the sketch artists.

Face landmarks are defined as certain characteristic points on the face, which are used to determine facial features. Facial landmarks include eye corners, eyebrow arcs, mouth corners, nostril corners, chin, ear lobes, nose tip and face edges. Facial landmark point detection or localization is an important preprocessing step in majority of automatic face processing task including face recognition, gesture understanding, face tracking, expression recognition *etc.* Facial landmark points are important are used to extract features for modeling the face processing tasks. The facial landmarks can be demarcated manually or automatic methods can also localize them.

Anthropometric and statistical model based methods are generally used for synthesizing age progressed facial images. Age progression can also be generated using image morphing. Although the output image may be not as realistic as an artist's drawing, it serves as good approximation of the age progression. Moreover, image morphing includes several parameters that allow controlling the appearance of the output.

In this thesis, we have proposed a method for producing age progressed face images of a child using image morphing technique. We proposed a semi-automatic method for localizing facial feature points and a triangle based method for image warping is also devised using the landmark points.

1.1 Issues

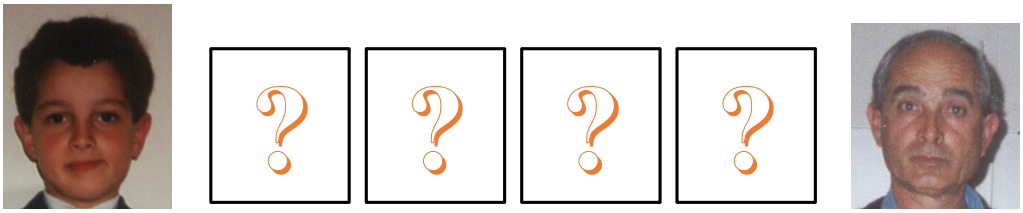
To complete this work we had various difficulties like input images are non uniform, they are not properly aligned, sizes are different, some images are color images whether some are gray scale images, *etc.* The major challenging issues, we found are:

- Issues due to variations of input images, *e.g.* illumination, pose, facial expressions, variability due to aging, *etc.*
- Health, genetics and lifestyle, ethnicity related issues.
- Smoking issue; smoking can speed up the normal aging process of one's skin.
- Exercise and healthy lifestyle; a good exercise and healthy/ satisfying lifestyle can slow down the aging process.
- Heavy make-up, plastic surgery involves the restoration, reconstruction, or alteration of the human faces.
- Gender related differences:
  o Boys and girls differ only slightly in growth rate in first 12 years, o After 12 years girls grow a little faster than boys,
  o Then, after 18 years boys get ahead of the girls and grow faster.

1.2 Motivation

Age progression or facial aging has various real life applications,

- To find missing children.
- Prediction of the present facial appearance of wanted, missing persons, criminals *etc.*



(a) (k) (b)

Figure 1.1: Problem definition, (a) source, (b) target, (k) output images, which are older than source and younger than target. What will be the look of source at age k? Where age k is in-between age of source and target.

- Automatic updation of any employee's photographs or any photo identification documents/ databases.
- face recognition for any aged persons.
- Automated age and gender verification *etc.*

As discussed in the next chapter, age progression approaches can be divided into three categories - prototype-based, anthropometry-model-based and deep learning based approaches. The anthropometry or physical model-based methods are often complex and computationally expensive. They require a large number of face sequences of the same person with continuous ages. These disadvantages make it difficult to obtain realistic results from physical modeling. The prototype approach does not require large number of face sequences of the same person. Deep learning-based methods also require large set of training data which is scarce. Moreover, there is scope for improving the performance of prototype-based methods. Therefore, we are motivated to develop a non-parametric prototype based facial aging method that uses warping and morphing.

1.3 Problem Definition

Input: (S, T, k, a, b), where source S is a face image of a child, target T is a face image of older person and k, a, b are ages of output, source and target images respectively.

Output: (P_k), where P_k is the predicted image of S at age k, which is the output of the synthesized older face image of the given child S, $a < k < b$.

The problem is visualised in Figure 1.1, in this problem we choose the target T, the older face image which may be the older image of any family member like brother,

sister, father, mother, *etc.*, or any close relatives of the input image. The decision to select the target T, *i.e.* older model image totally depends upon the different choices of different users. Since, to draw a sketch of missing person, the artists draw the sketches keeping some visual descriptions of a target in mind, therefore we also keep this type of target images to solve the problem which will find the older images of a given child.

1.4 Contributions of the Thesis

The main contributions of this thesis are:

1. A semi-automatic technique to detect a face image and localize facial feature points is proposed,
2. A triangulation based image warping method is proposed,
3. A technique to get the predicted future images of a given child's face is presented.

1.5 Organization of the thesis

The thesis is organized as follows:

- Chapter 2 presents the works relevant to the research reported in this thesis. The review includes existing technique of age progression for facial images.
- Chapter 3 presents a technique to extract a face image and localize the facial landmark points of a given image.
- Chapter 4 presents a technique to warp a face image using a triangulation method based on facial landmark points.
- Chapter 5 presents a method to produce synthesized future images of a given child using morphing technique.
- Chapter 6 presents experimental results for the proposed method.
- Chapter 7 presents the general conclusions and gives a perspective on future work possibilities.