

Smiles vs chewing vs speech detection by similarity matching

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Abstract

This is abstract.

Acknowledgements

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Chapter 1

Introduction

This is Introduction.

1.1 Motivation

1.2 Thesis

1.3 Contribution

Chapter 2

Background

In human-human communication, human would be able to understand each other through multiply ways. Human is able to understand others by conversation, facial expression, gesture, even intonation, mood. This phonomenon was introduced into human-computer interactions(HCI). Using computer to automatically analyze human face, voice and behaviours would be helpful in imporving HCI. This techniques not only can be used in avoid impostor attacks but also be used in automatic speech recognition. Face and voice are important and personal biometric characteristics. Compare to traditional knowledge-based and token-based person recognition method, biometric recognition technology are more convenient and safer. With the increasing in computer computing power and development in computer vision, Automatic Speech Recognition(ASR) attracts more attention in recent years, from traditional audio-only ASR to audiovisual ASR, a huge progress was made in ASR.

2.1 Automatic Speeech Recognition

Intuition of Automatic Speech Recognition is to convert a spoken sentence into to readable text in real time by computer. It has been researched over 50 years, and the ultimate goal of ASR is to let a computer 100% accurately recognise speech of any person under any environment. However, the accuracy of recognition highly depended on robust information channel, background environment, the training data base and the adaptation of speaker to database. The beneficial of ASR is quite obvious, it can help deaf people listening by convert speech into readable text and help hard-reading people on reading by convert readable text into voice. The search engine may not be limited on text searching but also speech search. With decreasing price of computing power, Speech recognition techniques are widely used on mobile devices, like siri.

As in human-human communication, visual feedback is very important, visual information plays an important role in helping people understanding each other. Visual modality was proved to have positive influence on reducing noise in ASR and the history can be quantified back to 1954 [5]. Deaf people is able to communicate with each other by reading mouth movements. [5] gave three key reasons to include vision information in human speech recognition. Firstly , it helps audio source localisation, visual information of tongue, teeth, and lips provide complementary information of articulation. It is beneficial for distinguish confusable acoustics such as unvoiced consonants /p/ by providing information of facial muscle movements. Facial muscle movements are robust information for ASR. This technique of using visual information to recognise speech is known as automatic lipreading or speechreading in ASR [5].

Audiovisual ASR uses both visual modality and audio modality in recognizing speech. Two main challenges are introduced by AV-ASR, how to extract visual features, how to combine it with audio features. Visual speech information mainly from speaker's face. Extract visual feature requires face detection, face alignment, tracking, feature extraction and other techniques to extract useful visual information from image with a face. Combination of two modality are also a challenge for AV-ASR.

2.2 Visual Front End

A major problem in audiovisual automatic speech recognition is extracting visual feature from images, the inputs are usually videos and the output should be visual speech features. Generally, visual speech feature can be classified as three types: appearance feature, shape feature, combination of both [5]. The image of Region of Interest used to be directly used for training and classification. However, image data contain many noises and influenced by the lighting condition. Then some techniques in computer vision are used to extract image features from Region of Interest. Image feature contains points, edges, texture, colors and so on. Shape feature usually means contours of speaker's face, specifically speaker's lips or including jaw and cheek. Shape feature usually means geometric-type features, such as statistical shape model or image moment descriptor of mouth, these model would be able to contain the information of the height, width and other information of a mouth. Combined feature usually is the joint of both shape and appearance feature vectors or a model that include both features like active appearance model.

In order to get appearance feature and shape feature or combined feature, there are some preprocessing before extracting feature. Face detect, tracking, alignment, and ROI extracting technique are needed. In order to align a face with feature points, some statistical models are used to fit the face. In order to remove head-pose, some technique are used to decompose the head points. If the head is not facing the front, appearance of face would not be correct, warping technique are also needed.

2.2.1 Face Detection

Several main aspects that influence face detection is background, head pose and lighting. [5] reports that many system uses traditional image processing techniques, such as color segmentation, edge detection, image thresholding, template matching or motion information and some using statistical modeling and neural networks. Once a face is detected, use face alignment technique to locate several facial feature around the face.

2.2.2 Region of Interest

The choice of Region of Interest(ROI) is according to the purpose of project. In AV-ASR it usually include large part of the lower face, such as the jaw, and cheeks or even the entire face [5], as when people speak, the lower face would show some movements. In my project, the ROI only contains the grayscale values of mouth region, which is scaled to $8 * 32$ size square region. [5] report that experiments shows that including jaw and cheeks was beneficial. As the tracker I use for tracking face does not include the jaw and cheek of the face, I have to just include the mouth.

2.3 Facial Expression

2.4 Nonlinguistic Vocalization

Chapter 3

Processing and Methodologies

In this chapter, I will introduce the procedure of extracting facial features and the tools and methodologies I use.

3.1 Processing Flow

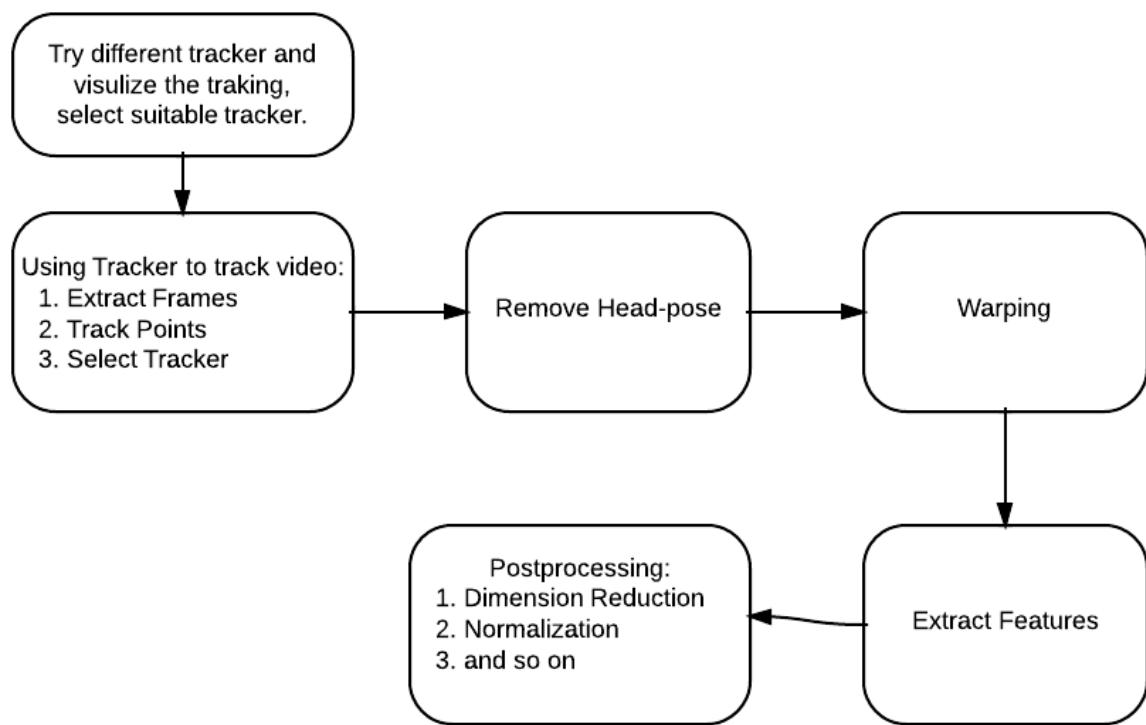


Figure 3.1: Main Procedure

Processing Chart Figure 3.1 shows main procedure of the whole project. At beginning, I tried several trackers. Intraface and DRMF are two trackers I tried and compared most. Two trackers are using different methods and also implemented in different languages. Intraface are programmed in c and matlab and has great interface for matlab. I tried two version of DRMF, DRMF programmed using CUDA which uses parallel processing is quite fast. As the programme of DRMF doesn't integrate extract frames from videos. The images are extracted using external function, then tracked using DRMF. I choose Intraface as the final choose, the reason and comparison will be given in later section. Remove head-pose seems to be a very important part for this project, as subject's head moves frequently in many videos. After having tracking points without head-pose,

each face in each frame is warped and scaled to same size grey image. Extracting features is to extract appearance feature of each face in the image. Post-processing is preprocessing before using the data for classification.

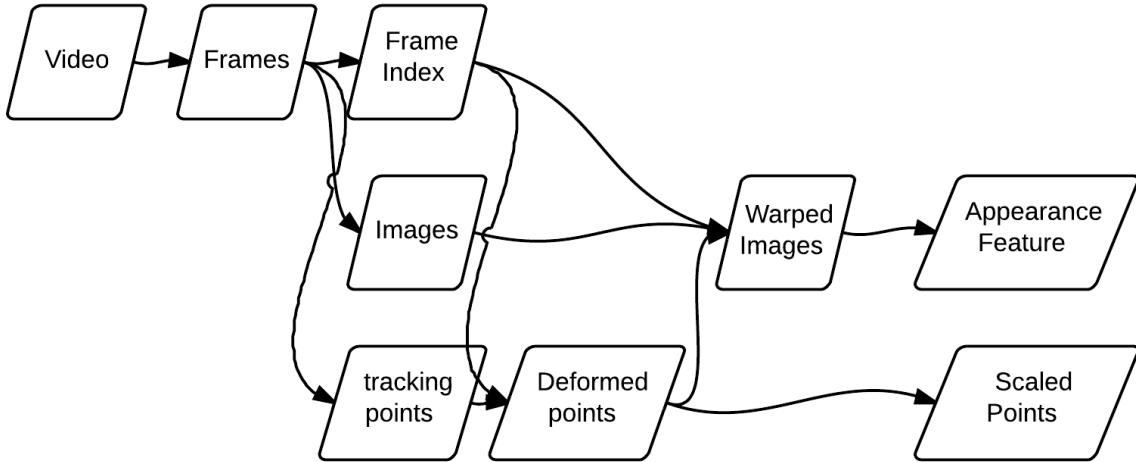


Figure 3.2: Data Flow

Data flow Chart Figure 3.2 show data I need for processing. There are two types of encoded video, one is in format of fly and the other is avi. Extracting frames from videos is proceed with Intraface and stored in formats of jpeg and mat which used for processing of matlab. There are several situations that a track is unable to track a face in the image such as no subject in the image, the head is face to a very large angle from frontal face, face is partially not show in the frame. Frame index points to those images which the tracker is able to tracker a face in a frame. Image is the frame images stored in mat format. Different tracker may tracks different number of characteristic facial points. Intraface tracks 49 facial points and DRMF tracks 66 points. Deformed points is the tracking point after removed head-pose. Warped Images is the face after remove head-pose and background which only leaves the meshes build by tracking points. Appearance feature is face feature extracted using local binary pattern (LBP). As the image size from image to warped images are changed, the points is rescaled from deformed point to scaled points.

3.2 Face Alignment

Face alignment is to align face in one image with respect to the same face in another image. Face alignment techniques are used to track characteristic facial points in image sequences. In this project, the aim of face alignment is to localise the feature points on face images. The points are usually around eyes, nose, mouth, and outline. Face alignment techniques are essential on face recognition, modelling and synthesis. There are three main different approaches Parametrized Appearance Models(PAMs), Discriminative approaches, Part-based deformable models. Parametrized appearance models contains many models such as active appearance models (AAMs), morphable models, eigentrackings, and template tracking [8]. All these models are using PCA method to parametrize a face. A face could approximately decomposed as linear combination of shape basis and appearance basis. The problem of face alignment could be refer as minimising the difference between the constructed PAM and the face. Common approach is use Gauss-Newton methods [8]. Discriminative approaches are to learn the linear regression between the head move and appearance change. Part-based deformable model perform face alignment by maximising the posterior likelihood of part locations given image [8].

3.2.1 Active Appearance Model

Active Appearance Model (AAMs) is defined as a generative model of a certain visual phenomenon in [4]. AAMs are conceptually related to morphable models, constrained models and active blobs. In this project, it is refer to a model of face. As AAM is conceptually related to other parameterized appearance model, so it is introduced as an example of parameterized appearance model for understanding purpose. According to [4], there are two types of AAMs, one refers as independent shape and appearance models, which model shape and appearance independently, and the other refers as combined shape and appearance models, which parameterized shape and appearance model with a single set of linear parameters [4]. Normally AAMs appears along with a fitting algorithm. However, in the following context, it only refers to a model. [4] gave a well explain about what is an AAM, most of following theory are from [4].

Shape Shape of a face s is defined by coordinates (x, y) of v vertices of face points and the mesh they built:

$$s = (x_1, y_1, x_2, y_2, \dots, x_v, y_v)^T \quad (3.1)$$

s also can be expressed as a base shape s_0 plus linear combination of n shape vectors s_i :

$$s = s_0 + \sum_{i=1}^n p_i s_i \quad (3.2)$$

Appearance For all pixels x in the mesh s_0 , appearance $A(0)$ can be expressed by base appearance $A_0(x)$ and m appearance images $A_i(x)$.

$$A(x) = A_0(x) + \sum_{i=1}^m \lambda_i A_i(x) \quad \forall x \in s_0 \quad (3.3)$$

AAMs are usually computed by applying Principle Component Analysis (PCA) to choose images. The chosen images contains a variety of shapes. The base shape s_0 is the mean shape and the vector s_v is the eigenvector corresponding to the largest v eigenvalues. The base appearance A_0 and the appearance A_i is computed by applying Principle Component Analysis to a set of shape normalised images.

Model $W(x : p)$ is the warp from s_0 to s . Then the model M set the appearance of $W(x : p)$ to $A(x)$.

$$M(W(x : p)) = A(x) \quad (3.4)$$

Combined AAMs

Combined AAMs just use parameter $c = (c_1, c_2, \dots)^T$ to parametrize shape:

$$s = s_0 + \sum_{i=1}^l c_i s_i \quad (3.5)$$

and appearance:

$$A(x) = A_0(x) + \sum_{i=1}^l c_i A_i(x) \quad (3.6)$$

3.2.2 Trackers

There are many different trackers for tracking facial feature points. Different tracker may use different approaches, so they may be applied into different situations. I tried two main trackers for tracking characteristic facial points, one is Intraface [8] which use supervised decent method, the other is DRMF [1] which use discriminative response map fitting. Those two trackers not only using different approaches, the number of landmark points are also different.

Intraface [8] implies image alignment can be posed as solving a nonlinear optimization problem. It uses Supervised Descent Method for minimising Non-linear Least Square(NLS) function, which avoids calculating the Hessian and the Jacobian that could be computationally expensive. The running time of Intraface shows that the method is very effective and efficient.

Tracking Points The following tracker show the tracking points of Intraface. This tracker tracks 49 facial feature points. As you can see the eyes, nose, mouth, unfortunately the jaw and cheek may contain visual information that would help classification. Without the bound of face, I am unable to extract the region as I can not do warping of that area.

Eating and Talking Sequence Figure 3.3 show a sequence of image of eating tracked by Intraface. The point are aligned very precisely along the face. Figure 3.4 shows a talking sequences of image tracked by Intraface. The landmark points of mouth is very accurate.



Figure 3.3: Eating sequence tracked by Intraface



Figure 3.4: Talking sequence tracked by Intraface

DRMF DRMF uses novel discriminative regression based on Constrained Local Models(CLMs) for face alignment. The basic idea of DRMF is to fit a face for each frame of a video. After locating the position of a face, the tracker tries to fit a trained constrained local model to fit the face. Sometimes the fitting result is not very good and the landmark points of mouth region is not very accurate.

Tracking Points DRMF tracked 66 facial feature points, the extra 17 points are the point around face bound. Other landmark points are the same with Intraface.

Talking and Talking Sequence A image sequences of eating tracked by Intraface is shown below.



Figure 3.5: Eating sequence tracked by DRMF



Figure 3.6: Talking sequence tracked by DRMF

3.2.3 Comparison

The following are some examples for comparing two trackers. There are two version of DRMF tracker one is implemented by CUDA language the other is by C language. Although the C version of DRMF is very slow and very easy to run out of memory, the version implementd by CUDA is very fast as CUDA is using parallel computing. However, DRMF is not as accurate as Intraface and not suitable for this project. In many situations, DRMF try to fit a face and the fitting result is awful. The images with red points are tracked by Intraface, and the images with blue points is tracked by DRMF.

From figure above, it seems both tracker can only be used to trak one face at one time. DRMF detect the smaller face instead of the bigger one is possibly because of the algorithm. The second and third frames are tracked by DRMF is not very accurate on the nose area. As the track point of mouth, intraface is better than DRMF. In some frame, partial of face is out of frame. Intraface is better dealing with this type of situation. Intraface ignore those points that out of the images. DRMF tries to fit a face forcibly. It often lead to bad influence on the traking result shown in the figure.



Figure 3.7: Tracking result, red points tracked by Intraface and blue points tracked by DRMF



Figure 3.8: Tracking result, red points tracked by Intraface and blue points tracked by DRMF

3.3 Remove Head-pose

The algorithm of removing head-pose from tracking points is in [6]. The following are some example of original track points and deformed points. Remove head pose of face and the warp the face to frontal direction is the most important part of extracting appearance feature. Here are two examples, from example one, rotation on x-y direction is mostly removed. In example two, the algorithm also show some efficient on remove head-pose of x-z direction and y-z direction.

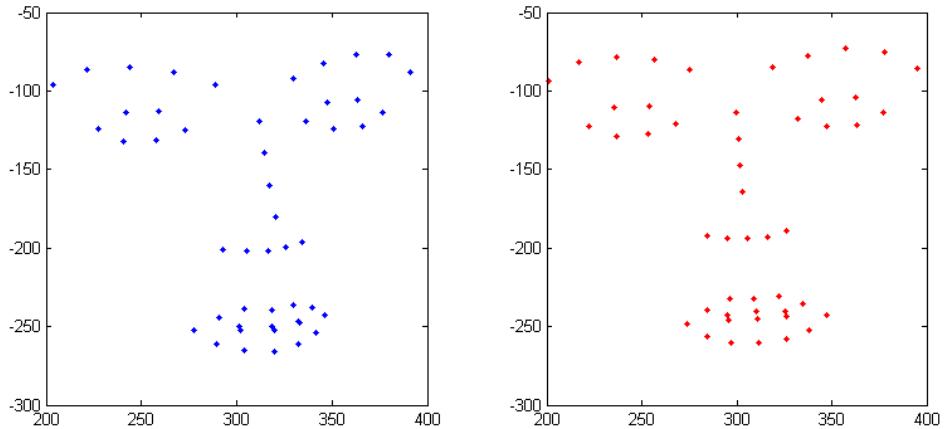


Figure 3.9: Traking points and Deformed Points, Example 1

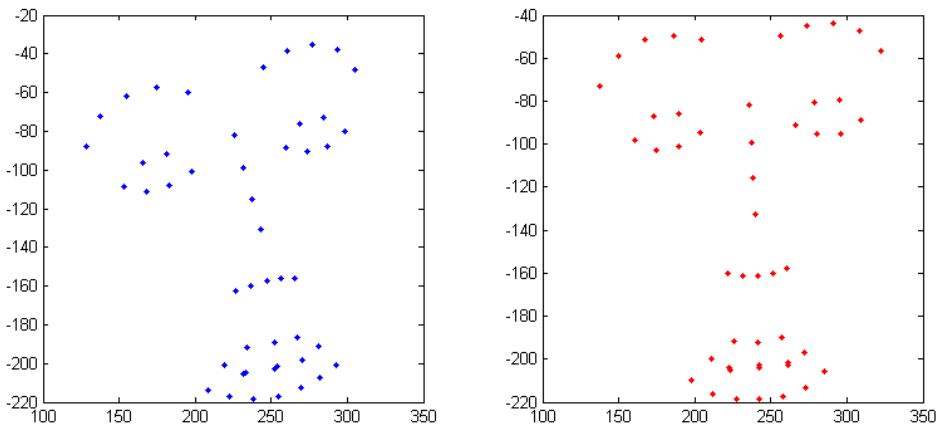


Figure 3.10: Traking points and Deformed Points, Example 2

3.4 Warping

In order to have the appearance image of the face after removed head-pose, it is necessary to warp the face with head pose. Basic idea is to for each triangles builded by shape points, the image points in the triagnles are projected to the corresponding triagnles built by deformed points. The following are some examples of face before and after warping:

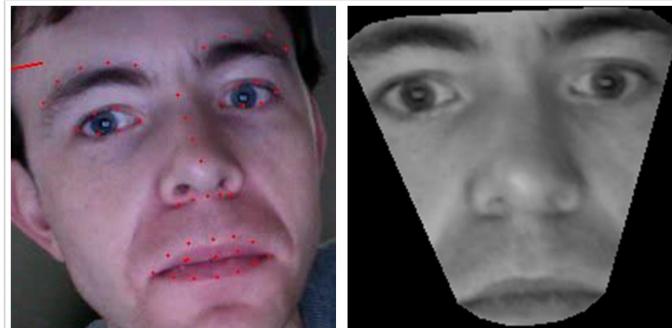


Figure 3.11: Talking sequence tracked by DRMF

3.5 Feature Extraction

The image after warping is not directly used for classification, image feature are selected to represent the image. Points, edges, objects and texture are important features of an image. In this project, Local Binary Pattern are used for classification as it's a very powerful feature for texture classification.

3.5.1 Local Binary Pattern

LBP is chosen to be the feature for representing region of interest. [7] obtained best recognition result by using Support Vector Machine with Boosted-LBP features. Moreover, [7] shows LBP features perform stably and robustly on low-resolution face images. In the beginning, LBP was used for texture analysis, it has natural advantage on computational simplicity and ignoring illumination changes.

3.6 Postprocessing

As it is known large margin classifiers are sensitive to the way features are scaled, it's better to normalize either the data or the kernal function [2]. Feature of a image is represented by a vector, the number in the vector would influence the weight of feature in this dimension. As I would like to treat each dimension similar, I scale the number in the range of $[0, 1]$.

Normalization The performance of SVM is usually better if the data is normalized. There are two ways of applying normalization, standardizing the input features or normalizing the kernal function. As I am using the builtin function of libsvm [3], so I standardising the input features by subtracting its mean and divide by its standard deviation.

Scaling The range of appearance feature vector and shape feature vector is different. I would like to treat them as the same. So I scale all the vector into the range of $[0, 1]$, by subtract the minimum and divide by the maximum number of each dimension.

Chapter 4

Experiment and Results

4.1 Database

4.1.1 Feature and Data

4.2 Methodology

RBF

4.3 Experiments

4.4 Results and Analysis

Chapter 5

Conclusion and Future Work

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