



Facial Recognition Technology

Version: 1.0
Release Date: 29 September 2011

INTRODUCTION

Traditional image search systems rely on the user specifying words to describe the images that they are looking for. These keyword-driven systems mean that the user is required to select words that are associated with the images to have any possibility of finding the images required. In many instances, the words used to describe the images interested are not necessarily those words attached to the images – resulting in a frustrating experience for the user, trying to best guess the words to use in the search.

Traditional search systems are greatly limited by the language of the keywords, i.e. you cannot describe the image in French if the keywords of the images are in English. Unlike traditional search paradigms, Imprezzeo's solution allows the user to search for images using images, i.e. using images to find images. In other words, they do not have to rely on entering keywords to find the images. Imprezzeo's approach allows the user to use one or more images as the reference images to search for image(s) that look like the reference images.

Imprezzeo Image Suite is a similarity search engine, developed to complement the traditional keyword-driven image search systems. Imprezzeo provides users of image search systems the ability to search for similar images by using reference images, rather than relying on metadata describing the images. In other words, users have to simply choose one or more reference images that best represent what they are looking for and call Imprezzeo to find images that are similar to the reference images. This makes image searching more intuitive and provides a richer and satisfying user experience.

Visual search is a paradigm that enriches the user experience in image search systems. It provides the user with the ability to visually specify the type of image he/she wants. It is not driven by metadata, but relies on one or more reference images selected by the user.

WHY IMPREZZEO?

There are a number of vendors offering similar solutions to Imprezzeo. What makes Imprezzeo different is our unique search engine. Imprezzeo seamlessly

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incorporates two disparate technologies into a single solution – Content Based Image Retrieval (CBIR) and Face Recognition (FR).

For a more detailed discussion on Imprezzeo's unique search capabilities, refer to our paper "Imprezzeo – Innovation in Visual Search". This paper focuses on the facial recognition technology of the Imprezzeo Engine.

FACIAL RECOGNITION TECHNOLOGIES

The Wikipedia definition of facial recognition is an appropriate definition:

A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database.

The majority of facial recognition solutions are based on a number of common approaches or algorithms. A common approach is to measure the relative distance between the eyes, ears and nose of a face detected in an image. These measurements are then used in an algorithm to derive other faces with similar features. Another approach is to use an image as a yardstick and applying templates of matching techniques.

Irrespective of the techniques or algorithms that facial recognition systems deploy, none of the systems can claim to provide 100% accuracy in determining the identity of a face in an image.

Popular recognition algorithms include Principal Component Analysis with eigenface, Linear Discriminate Analysis, Elastic Bunch Graph Matching fisherface, the Hidden Markov model, and the neuronal motivated dynamic link matching.

THE CHALLENGES

All facial technology solutions are faced with the same set of challenges. They are dependent on the ability to process the relative distances of the eyes, ears or nose. This dependency alone requires that a face in an image will need to

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be fairly full frontal before it can be successfully processed. Hence, majority of passport control at border security systems require the passport holder to be facing directly towards the camera. This requirement is generally termed as 'passport quality' images, i.e. images with a full frontal head shot of the person.

In practice, images of people are not usually full frontal, unless they are in a photo shoot situation. Most images with people in them would have only a partial view of the face, part of the face is in shadow or obstructed, the viewing angle of the face, e.g. the face is tilted at an angle or away from the camera, both eyes of the face are not completely visible or the person is wearing sunglasses that covers the eyes. These faces, generally, will not work in facial recognition deployed in security systems.

Another challenge in facial recognition technology is the ability to recognise the faces in an image. Whilst the human eye and brain can combine easily and effectively to identify personalities in an image (e.g. dad, mum, Uncle Joe, etc), a computer-based system requires the parameters to conform to its strict requirements before it can process an image with any meaningful output. Hence, the base requirement of sighting the eyes and ears of a face in an image is one of the biggest limitations of facial recognition solutions. They generally do not work with real world images, i.e. these systems are unable to automatically process the identities of faces in an image because they fundamentally cannot even detect the faces because of the strict requirements of sighting the eyes.

Facial recognition systems require an understanding of the features of a personality whom they are supposed to recognise and identify. This is usually referred to as the reference point for the personality. In Imprezzeo, we refer to this as the persona. The creation of a persona requires sample images of the personalities. Some facial recognition systems require only 1 sample image to start with, whilst others require more, some 30 – 40 samples images. The reality is that the smaller the size of the sample images, the less accurate will be the recognition and identification of the faces in the image processed.

IMPREZZEO'S FACIAL RECOGNITION TECHNOLOGY

The Imprezzeo Facial Technology is developed using a combination of a number of the popular recognition techniques outlined above. The Imprezzeo Engine has been developed to handle real world images. Having said that, Imprezzeo does not claim to provide 100% accuracy from its recognition and identification abilities. However, Imprezzeo has developed a number of techniques in its facial image processing workflow that will provide a high degree of accuracy once the images pass through the processing workflow.

Imprezzeo has incorporated the Facial Recognition technology into its core engine and the facial technology is simply regarded as an extension to its similarity search capabilities. In other words, the facial recognition technology is treated as an additional feature that is used in the algorithm to determine similar images.

Imprezzeo differentiates the facial recognition capabilities into two categories:

- Face Detection
- Face Recognition and Identification.

FACE DETECTION

The Face Detection capability in Imprezzeo literally counts the number of detected faces in an image. With each face that is detected in the image, Imprezzeo assigns a dominance factor, i.e. how dominant is each face in the image relative to the other faces.

When an image is processed, Imprezzeo will count the number of faces in the image and calculate each detected face's dominance factor. These are then treated as an attribute for the image, just like any other attributes that are extracted, e.g. Colour Layout, Colour Histogram, Edging Information or Texture Information. These attributes are used when searching for images that are similar to a sample image.

The benefits of this Face Detection feature are:

- It provides the user the ability to search for images with similar number of people. For example, the user may want images of an office meeting with 2 to 3 people gathered in the meeting room. The Face Detection

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capability in combination with the Content Based Image Retrieval (CBIR) technology in Imprezzeo allows the user to search for such images quickly and effectively;

- The user may require head shots of the members of a sports team, e.g. a favourite football team. Using traditional keyword based search systems, it is impossible to locate head shot images of the team members. However, Imprezzeo's Face Detection technology will allow for this type of search to be realised, since it knows the number of faces in the sample image of a head shot (i.e. 1) and its associated dominance factor (i.e. face is very dominant in the image). The combination of CBIR techniques will provide a resultant set of head shots of the players in the team, based on their team jersey.

FACE RECOGNITION AND IDENTIFICATION

The Face Recognition and Identification capability can recognise and identify any known personalities that are in the images. This capability assumes that you have trained the Imprezzeo Image Suite to recognise nominated personalities.

Imprezzeo provides you with a methodology to process facial images, i.e. images with faces that you want to identify the personalities. The methodology consists of a number of stages:

Stage 1 – Creating the Persona

In Stage 1, Imprezzeo expects to have the data to perform the recognition and identification. This data (which Imprezzeo refers to as 'the persona') is likened to a fingerprint of the personality. It will uniquely identify the personality to Imprezzeo. The Imprezzeo Workbench provides the functionality to create and modify personas.

The creation of a persona involves assembling about 15 – 20 images of the personality. These images are passed through the Imprezzeo Facial Image Analysis process. The output of this process are images with any detected faces marked. The user then simply identifies the faces that are of the personality of interest. Once this is done, the images are passed through the Imprezzeo Persona Creation process, where the persona is created.

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Once the persona is created, a confidence score is attached to the persona. This confidence score is an accuracy indicator, (i.e. based on the images used to create the persona, Imprezzeo calculates the expected accuracy in determining correctly the personality if he/she shows up in other images).

This score provides an instant indicator to the user, with which the user can decide whether or not to obtain additional or better quality images and re-create the persona.

Personas are stored in the Imprezzeo Repository and are used as the 'fingerprint' to recognise and identify the associated personality in images. The personas can be exchanged with other Imprezzeo systems that are configured to support the Face Recognition capability.

Stage 2 – Facial Image Analysis

Stage 2 of the methodology involves processing images and performing the recognition and identification function. The Imprezzeo Workbench provides this functionality.

For each detected face in any image, Imprezzeo will attempt to recognise and identify the face. For every attempted identification, Imprezzeo attaches a Confidence Score with that face. This Score allows the user to decide what to do with the image, based on the Score.

When the Facial Image Analysis is completed, the images are sorted according to their Confidence Scores. The user is provided with the ability to set two thresholds, an Upper Score and a Lower Score. These thresholds are used to categorise the images into 4 categories:

- Images which contain all of its recognised faces that have scores above the Upper Score.
- Images with at least one of the recognised faces having scores below the Upper Score, but above the Lower Score or an unrecognised face. Images with all of its recognised faces that score between the Upper and Lower Scores are also in this category.
- Images with recognised faces that score below the Lower Score.
- Images with no detected faces.

These categories allow the user to decide what to do with each category of images in their image processing workflow system. For example, images in the

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first category (with scores higher than the Upper Score) may be allowed to go through directly to the production system. Images in the second and third category may be sent to a human agent to manually confirm the recognition and identification and correct any errors.

Once the images are processed, their attributes are updated in the Imprezeeo Repository. These face recognition attributes are used when performing a similar search with Imprezeeo. This allows the user to find images that contain a particular personality or a number of known personalities.

Strengths of Imprezeeo's Face Recognition Technology

Imprezeeo face recognition technology has been developed to provide a methodology that will ensure a high degree of accuracy in its recognition and identification. The methodology is developed on the fact that no face recognition solution is capable of fully automating the recognition and identification of faces in images. Moreover the majority of face recognition solutions give a lower than expected accuracy.

Imprezeeo recognises the limitations of face recognition technologies and provides a methodology that will greatly enhance and increase the accuracy and efficiency of recognising and identifying personalities in images.

The Imprezeeo face recognition and identification methodology provides flexibility that can be used by the user. The Upper and Lower Score thresholds allow the user to define the tolerance level of automating the image processing stage or, alternatively, sending a selection of the images already processed to a human agent for verification. During the human agent verification process, the human agent may be able to identify additional faces in the images that the computer-based systems cannot pick up. This flexibility greatly increases the accuracy of the identification and provides highly accurate results.

The personas created for Imprezeeo can be shared amongst other Imprezeeo systems. This will reduce the costs of creating and maintaining personas for your system.

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Moreover, the personas can be re-created without having to re-process all the images in your collection. You may choose to re-create the persona if you want to have the persona handle the personality over a wide period of time, e.g. from their youth to their old age, or you may want to re-create the persona to attain a higher Confidence Score for the persona.

The Imprezzeo Face Recognition technology can be also used simply to detect faces in images. The ability to search for images with a similar number of faces and associated dominance factor provides a great leap in the user experience of search systems that incorporates Imprezzeo.

Facts and Figures

The Face Detection improvements are measured against two criteria:

- The Positive Detection Rate
- The False Detection Rate

The Positive Detection Rate is a measure of how accurately the Imprezzeo Engine detects faces in any image, while the False Detection Rate is a measure of the false alarms returned by the Face Detection in the Imprezzeo Engine.

The ideal performance is for 100% Positive Detection Rate and 0% False Detection Rate. In reality, this is impossible. As such, the Face Detection in the Imprezzeo Engine is tuned for an optimal Equal Error Rate (EER), i.e. the cross-over point between acceptable levels of Positive Detection Rate and False Detection Rate.

The tests for Face Detection are executed against a test bed of 1,087 images with faces in each of them.

The Face Recognition test bed is a collection of 800 images and the Imprezzeo Engine is trained to recognize 100 personas. The accuracy of the recognition is measured.

The efficacy of the Imprezzeo Engine is tabled below.

	Imprezzeo Release 1.10	Imprezzeo Release 1.30
Positive Detection Rate	71.7%	77.4%
False Detection Rate	24.0%	11.0%
Positive Recognition Rate	63.0%	82.6%

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To successfully detect a face in any image, Imprezzeo requires the minimum interocular distance to be 19x19 pixels for the face.

ABOUT

Imprezzeo is a visual search technology company. Imprezzeo Image Suite provides an enterprise level solution that complements existing search systems, making it easier and faster for users to find the images they need. Our patented technology provides developer tools to enable rapid integration of visual similarity search and facial recognition functionality into existing search and content management systems.

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