2013

Adaptive Computation
LLC

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Whitepaper

["Study for Real World Object Recognition and Intelligent Video "]

Background

In this study, we provide the performances of our software algorithm for two objective tasks: detection and recognition of searching a selected random object from a random scene in movies using non-adaptive, adaptive technique. We also investigated how our bio-inspired visual algorithm is responded to aging object with some previous knowledge e.g. features from the same object in years earlier. The three movies used in this validation are longer than 2 hours and each consists of more than 166,000 frames (scenes). The inputs are image of objects which are cropped from random frames in the movies. The ADC algorithm processes frame by frame to search for exact and similar object based on given object input. The organization of this study is as follows: 1) Non-adaptive technique with two movies: "Message in a Bottle" and "An Officer and A Gentleman"; 2) Adaptive technique using "An Officer and A Gentleman (1982)"; and 3) Aging study with "An Officer and A Gentleman" and "Pretty Woman (1990)" where Richard Gere had aged for 8 years between two movies.

This study aims to demonstrate that our technology is robust even for large real world data set and ready for real world applications such as product search and intelligent video applications e.g., products advertisement in movie. This demo establishes two paths of approach: *real-time and on-line product recognition* and *fast autonomous index based product recognition* for product advertisement in the live TV, the movies, YouTube and videos. Furthermore, it also showed that it is robust to recognize the degraded object in time e.g., human face. This feature will open new opportunities in intelligent photo and video search where the photos and videos become overwhelmed even within their family members and peers. Our bio-inspired visual algorithm enables them to quick detect and identify them.

ADC uses proven and patented software and hardware solutions to bring the power of neural network processing to consumers and business alike. Developed by ADC founder Dr. Tuan A. Duong for NASA task and patented by Caltech, these technologies allow the company to deliver breakthrough content search and recognition solutions where noisy and partial object search, for the first time, is effectively delivered. ADC technologies are based on a mathematical and biological model of saccadic eye movements and visual pathway processes which are focused on shape and color (if available) recognition of the object.

To demonstrate our superior bio-inspired visual detection and recognition algorithm, the statistical study was conducted and reported in our previous white paper[i]. In this study, we only focused in movie as database to validate our software algorithm for searching object based on single image. This study is intended to convey two messages: robustness and readiness for real world applications and it is aiming to advertisement products in the movie for internet or smart phone platform.

To search products in movie, the ADC bio-inspired algorithm must be able to perform two tasks effectively: locating similar object features in the viewed scene if existed (e.g., locating the face in each scene) and estimating the similarity between input object and potential objects. These steps are posing the challenges current state of the art to deal with it. In the traditional study, the input object and test object are framed and the testing algorithms are only used to estimate the recognition algorithms to find the similarity match between them. However, locating a potential object in the scene is extremely challenge for current state of the art to perform and this is also

the crucial missing part for current object recognition software. For application perspective, several current face recognition approaches are not practical for real world applications except driver license image search where the faces are framed in controlled environment. ADC is focusing in the applications of real time, on-line and uncontrolled environment object recognition; therefore the locating and identifying object in the scene are the "musts" to demonstrate its readiness for commercial arena.

Application focusing

This study is conducted to aim two applications:

1. Products search for advertisement applications in movies, TV and YouTube
2. Intelligent video where desired product as input image is used to search through videos

Simulation results:

Non-adaptive technique

In this study, we used only single input image to search for exact or similar matches based on bio-inspired features from input image. We used two movies: "Message in a Bottle" and "An Officer and A Gentleman" in this case.

In this practical world, single image for search may be often available, specially product search and it is difficult to perform an effective search. In 3-D approach, it may expose its difficulties since the single image may not be suitable to extract in 3-D modeling. Moreover, this single image search can be implied for more ease for our algorithm to search with multiple images search.

Movie I (Message in a Bottle)

Input Image

We randomly selected a frame in the movie and extracted an object (like face) shown in Figure 1.

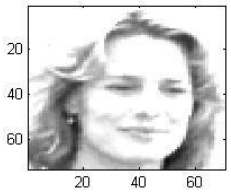

Figure 1 **Input object for searching in the movie I**

Searched output results

From the given input above, we are able to identify 66 similar objects (including exact match object) throughout the movie (166,000 scenes) with no single false alarm. Part of the similar match results are shown in Figure 2 below:

Figure 2: Some from 66 similar searched results with no error.

There is no errors in this search. However, these results have shown the discrepancy between input and output are not very much difference.

Movie II (An Officer and A Gentleman)

Input image:

We randomly selected a frame in the movie and extracted an object (like face) shown in Figure 3.

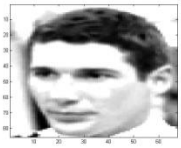

Figure 3 Input object for searching in the movie II

Searched output results:

From the given input above, we are able to identify 195 similar objects (including exact match object) throughout the movie with no single false alarm. Part of the similar match results are shown in Figure 4 below:

Figure 4: Some from 195 similar searched results using non-adaptive technique with no error.

Adaptive Technique

Movie I (Message in a Bottle)

When we used the adaptive technique in this movie, it improved from 66 to 72 similar faces of actress which is not significant.

Movie II (An Officer and A Gentleman)

For this study, we used the same single input shown in Figure 3; however, the last detected and recognized output will be used as adaptive input for searching.

From this adaptive scheme, we are able to identify 495 similar objects (including exact match object) throughout the movie with no single false alarm. Part of the similar match results are shown below:

Figure 5: Some from 495 similar searched results using adaptive technique with no error.

Obviously, adaptive technique provided much better solution than non-adaptive one.

ADC Detection and Recognition Algorithms Under Aging Challenge

Movie III (Pretty Woman)

In this section, we studied how our algorithms responded to aging face along with adaptive technique. We used two movies : "An Officer and A Gentleman" and "Pretty Woman" where Richard Gere had aged for 8 years between two movies.

The input for searching is shown in Figure 3, from the movie "An Officer and A Gentleman" and the testing data is the movie "Pretty Woman" and the simulation results has shown that it detected and recognized 70 similar objects (including exact match object) throughout the movie with no single false alarm. Part of the similar match results are shown below:

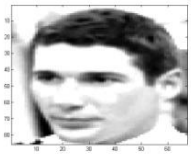

Figure 3 (again): Single input image of Richard Gere image in "An Officer and A Gentleman"

Figure 5: Some from 70 similar searched images of Richard Gere in "Pretty Woman" with no error.

Discussions

In the movie I and II, the searched results suggested that ADC algorithm can tolerate some degrees of discrepancy in size and rotation between input and searched output image; hence it can be simple and effective as 3-D synthesized approach when constructive multiple inputs are used.

From adaptive technique, each similar object output can feedback as a new input to search for new similar objects and from the simulation results it suggests that adaptive and feedback scheme enables to search for almost all of similar objects; hence it can emulate the human visual system in quantity.

In movie III, ADC has demonstrated it is also effective with aging object as long as aging object still remains sufficient feature/features of it. This suggests ADC will be very robust to detect an aging object if slow aging degraded sub-part/sub-parts (components) of object are selected for searching (because ADC is very effective with partial object detection and recognition).

Conclusions

From this study, ADC algorithm effectively searched for similar objects with single image from practical and sufficient database as movies where the several constraints in environment are often encountered. Moreover, ADC algorithm also demonstrated it can be effective for aging object as long as the aging object remains sufficient features of it;

With continuing of adaptive technique and feedback mechanism, single image can retrieve almost all similar objects: to enable synthesized-3D model with single image and to emulate our bio-visual system structurally. It suggests ADC technology is a right tool for product placement and advertisement in a movie and intelligent search.

[i] ADC White paper "Statistical Study for Partial Object/Face Recognition Based ADC Bio-Inspired visual Recognition"