SSRG International Journal of Electronics and Communication Engineering
ISSN: 2348-8549/ https://doi.org/10.14445/23488549/IJECE-V11I8P106

Volume 11 Issue 8, 55-61, August 2024


*Original Article*

# Skin Cancer Detection Using Ant Colony Optimization Based Content-Based Image Retrieval System

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Received: 30 May 2024 Revised: 13 July 2024 Accepted: 07 August 2024 Published: 31 August 2024

***Abstract*** *- "Ant Colony Optimization" (ACO) is an optimization technique developed from the social behaviour of ant colonies. The ACO is being implemented and used in many applications, including image processing. One of the recent developments in image processing is "Content-Based Image Retrieval" (CBIR). The "CBIR" method looks for similar images in the big dataset of images based on image content. This paper effectively integrates ACO with CBIR, and the proposed system is called ACO-CBIR. The proposed system is first tested on general images for its suitability. Further, it is used for detecting major skin cancerous images from large image datasets. It is found that ACO-CBIR performs better compared to basic strategies from state of the art and it detects skin cancer effectively.*

***Keywords*** *- ACO, CBIR, Benign, Malignant, Skin cancer.*

## 1. Introduction

Ant Colony Optimization (ACO) [1, 2] is an important member of Swarm Intelligence (SI) [3, 4] methods. The SI algorithms are approximate optimization algorithms that are based on the social and collective behaviour of simple agents like birds, ants, flies, fishes, wolves, bees, etc. Similarly, the ACO algorithm was created by observing the food finding behaviour of the real ants. The ants find the food source through their interactions. The main communication protocol between ants is the chemical called pheromone. When the ants travel from nest to food source, they lay pheromone on the tract and this becomes the means for finding the shortest path. The ACO finds lots of applications in the real world, including image analysis and processing.

The Content-Based Image Retrieval (CBIR) method finds the images that are similar to a given image in a large set of images. Image searching strategy in CBIR depends on image content itself. It excerpts the features of an image and builds a database of features for searching [5-7]. The "CBIR" based methods have become prevalent these days and attracted many researchers across the globe [8, 9]. Though CBIR is popular and a prime requirement of the day, it still needs improvements to increase its robustness and search efficiency [10, 11]. The CBIR system is also widely used in the medical domain for diagnosis. Human skin is one of the biggest organs of the body. This protects the human body from heat and infection. The human skin is subjected to more wear and tear, and it is exposed to harsh environmental conditions. Due to these aspects, the skin may get infected which leads to skin cancer [12]. Many a time, this turns out to be life-threatening, however, pre-diagnosis and treatment will reduce the risk to a greater extent.

This paper proposes a novel method for pre-diagnosis of skin cancer. The proposed method integrates the image feature extraction strategy of ACO with CBIR, called the ACO-CBIR system. This makes the CBIR more powerful and efficient in searching the images. The authors first applied the proposed method on well-known general images [13, 14] and validated the performance. Further, applied for detecting cancerous images related to skin from the popular image dataset [15]. It is found that ACO-CBIR performs well on almost all the images. The article is organized according to the below sections. Section 2 provides the details of the ACO algorithm, Section 3 deals with the CBIR system, and Section 4 explains the proposed system in detail. Section 5 contributes outcomes, and the conclusion is given in Section 6.

## 2. Ant Colony Optimization

Ant Colony Optimization (ACO) is the optimization strategy that is derived from the social interaction of real ants [1, 2, 13]. The main source of motivation for ACO is its food searching activities of real ants. During the food searching process, the ants first discover the area around their home randomly.

When they find the food source, they collect it and carry it to their home [1, 2]. While carrying food, they evaluate the quantity and quality in parallel. When they return home with food, they deposit pheromone on the way. The quantity of the "pheromone" being deposited is directly related to the concentration of food they collected. This chemical becomes the information for other ants to follow the path for collecting food and finding the shortest path to the food source. This social behaviour of ants to find the shorter path towards food is extracted, and an optimization algorithm is developed called Ant Colony Optimization (ACO) [1, 2].

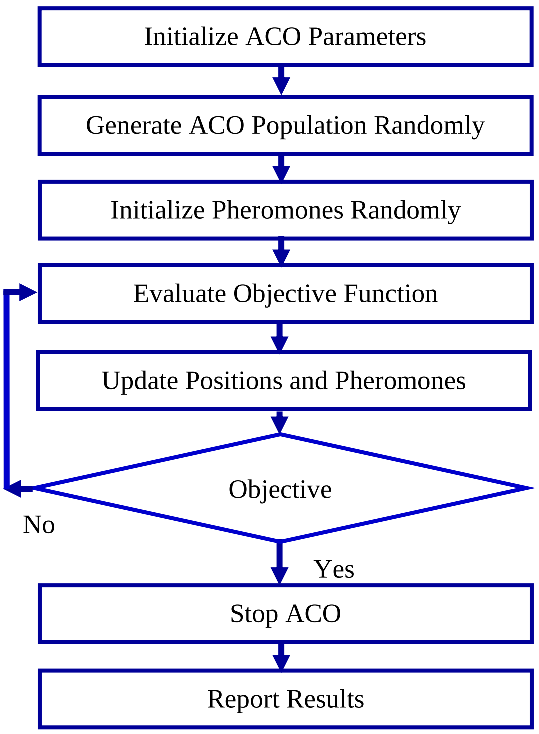


**Fig. 1 ACO algorithm**

The algorithm shown in Figure 1 explains clearly how the ACO algorithm is implemented and used for optimizing an objective function. The ACO is widely used in many real world applications, and the detailed survey can be found in [16, 17].

## 3. CBIR system

The Content-Based Image Retrieval (CBIR) system has become popular and very important these days. Its importance these days is attributed to the large number of images being generated and accumulated; further, their analysis has become cumbersome. Searching for images in these large sets of images is not only important but also difficult. The CBIR system seems a boon to this problem, as its search strategy is based on image content itself. The CBIR system first extracts the features of an image. Then, it constructs the image feature database, which makes searching for the required image easier. A simple explanation of this strategy is shown in Figure 2. Here the query image feature and features of images from the database are extracted. The images in the database that match the query image will be retrieved and presented.

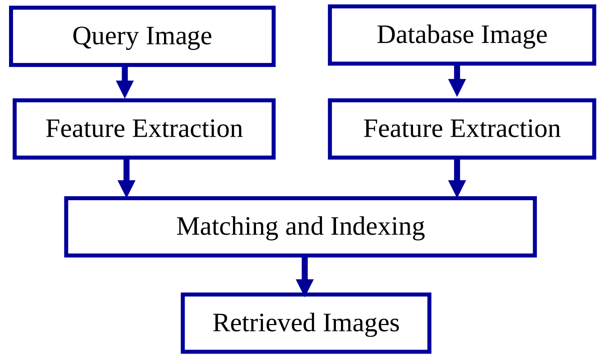


**Fig. 2 Basic CBIR system**

## 4. Proposed ACO-CBIR system

This section discusses the literature work and, in detail, explains the proposed method.

### *4.1. State of the Art*

Skin cancer is one of the most frequently seen among various cancers. This occurs due to changes in the skin cells, which may be due to UV light. It may be seen as bumps or patches on the skin. In recent decades, skin cancer has become more pronounced and has become an alarming health problem [18, 19]. There are many types of skin cancers found; however, melanoma / malignant are very scary. They have a high chance of human death [20].

Due to the advent of digital imaging tools, lots of skin cancer images are available. Thus, diagnosis based on these images has become quite possible. The cancerous images may be classified based on the color, texture and structure of the images. There are many classical methods available for cancer image identification [21]; however, they will take more time and effort.

There are methods based on CBIR used in radiology and pathology for cancer detection [26-28]. Authors in [29] have shown how CBIR is used for microscopic images based on searching more than one query image. The work in [30] has presented a detailed survey on CBIR for medical images. The work presented in [31] shows how CBIR is used for skin related diseases. Further, this work highlights multi-sourced features for reducing dimensional bias problems. The work in [32] integrates Neural Networks with CBIR in the diagnosis process.

### *4.2. Proposed Method*

This paper proposes a method of skin cancer identification and classification based on Ant Colony Optimization (ACO) and Content-Based Image Retrieval (CBIR) is called as ACO-CBIR system. The heart of the CBIR system is feature extraction from images. Thus, from the literature, it is quite evident that the ACO algorithm is a suitable candidature for image feature extraction. Thus it proposed to integrate ACO for feature extraction in the CBIR system. Figure 3 shows the proposed method.

The figure below describes how ACO is integrated with the CBIR system. Here, the image is taken and the ACO algorithm is applied on it to extract the feature. The feature extraction is completely based on the image content. The color images are converted into a Grayscale, and then they will be resized to known dimensions (say here, 200x200).

The resized image is 2-D; it will be converted to 1-D so that ACO can be easily used for optimization. These are then subjected to undergo ACO based iterations for extracting features. The features that are extracted, including query images, are stored. Then, as per the CBIR strategy, matching and indexing is performed on the features. Finally, the images are retrieved that are similar to the given query image.

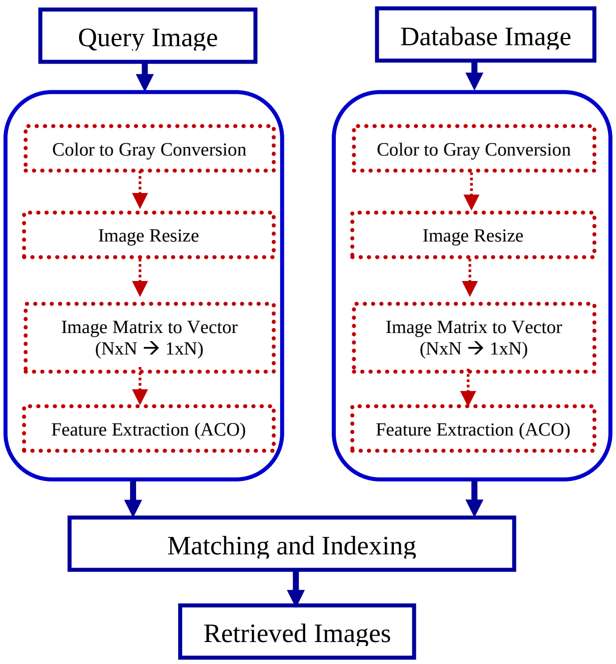


**Fig. 3 ACO-CBIR system**

## 5. Results and Discussion

The proposed ACO-CBIR system is realized in Matrix Laboratory software version 23a on the Windows operating system. The underlying processor is I7 with 2.5GHz speed. The database of images is taken from [13-15]. The states of the art used for comparison with ACO-CBIR are Edge Histogram Descriptor (EHD) [22], Color Layout Descriptor (CLD) [22] and K-Means (KM) clustering [23, 24].

ACO code for feature extraction and selection is taken from [25]. The proposed ACO-CBIR is first tested on general images taken from [13, 14] with well-known CBIR systems [22-24]. The images that are being considered for testing belong to the following categories. Airplanes, Buses, Cats, Dinosaurs, Dogs, Elephants, Roses, Sailboats and Sunset. Figure 4 shows all query images used in CBIR systems for retrieval. There are 100 images in each of the categories. To test the retrieving efficiency of CBIR methods, only 16 images are retrieved and presented. The results are presented in two forms; numerical and pictorial form.

**Fig. 4 Query images**

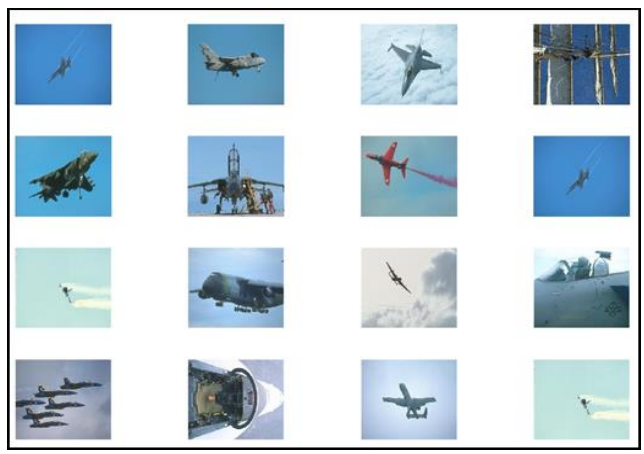

**Fig. 5 Airplane images retrieved by ACO-CBIR**

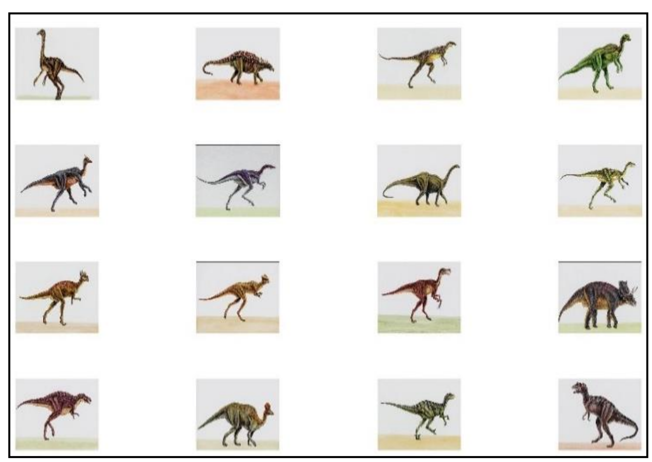

**Fig. 6 Dinosaurs images retrieved by ACO-CBIR**

Here, due to space, the images that were retrieved using the ACO-CBIR system are only presented. Further, out of nine categories, only two are presented. Figure 5 shows retrieved "Airplane" images, and Figure 6 shows "Dinosaur".

Figure 5 shows the number of Airplane images retrieved out of 16 images. The proposed system retrieves 15 out of 16 images effectively. Similarly in Figure 6 proposed system retrieved 16 out of 16 images. The numerical values are presented in Tables 1, 2 and 3. The numbers of images that are retrieved successfully are shown in Table 1. The sixteen images were planned for retrieval, and Table 1 shows the images retrieved by each mentioned method. Similarly, Tables 2 and 3 show the Precision and Recall results, respectively.

**Table 1. Retrieved images (16)**

| Images | EHD | CLD | KM | ACO-CBIR |
|---|---|---|---|---|
| Airplanes | 12 | 14 | 10 | 15 |
| Buses | 12 | 10 | 8 | 13 |
| Cats | 10 | 12 | 9 | 14 |
| Dinosaurs | 14 | 16 | 16 | 16 |
| Dogs | 10 | 12 | 7 | 15 |
| Elephants | 7 | 14 | 12 | 15 |
| Roses | 11 | 10 | 8 | 14 |
| Sailboats | 10 | 13 | 10 | 16 |
| Sunset | 12 | 11 | 8 | 14 |

**Table 2. Precision results (16)**

| Images | EHD | CLD | KM | ACO-CBIR |
|---|---|---|---|---|
| Airplanes | 0.75 | 0.87 | 0.62 | 0.93 |
| Buses | 0.75 | 0.62 | 0.50 | 0.81 |
| Cats | 0.62 | 0.75 | 0.56 | 0.87 |
| Dinosaurs | 0.87 | 1.00 | 1.00 | 1.00 |
| Dogs | 0.62 | 0.75 | 0.43 | 0.93 |
| Elephants | 0.43 | 0.87 | 0.75 | 0.93 |
| Roses | 0.68 | 0.62 | 0.50 | 0.87 |
| Sailboats | 0.62 | 0.81 | 0.62 | 1.00 |
| Sunset | 0.75 | 0.68 | 0.50 | 0.87 |

**Table 3. Recall results (16)**

| Images | EHD | CLD | KM | ACO-CBIR |
|---|---|---|---|---|
| Airplanes | 0.12 | 0.14 | 0.10 | 0.15 |
| Buses | 0.12 | 0.10 | 0.08 | 0.13 |
| Cats | 0.10 | 0.12 | 0.09 | 0.14 |
| Dinosaurs | 0.14 | 0.16 | 0.16 | 0.16 |
| Dogs | 0.10 | 0.12 | 0.07 | 0.15 |
| Elephants | 0.07 | 0.14 | 0.12 | 0.15 |
| Roses | 0.11 | 0.10 | 0.08 | 0.14 |
| Sailboats | 0.10 | 0.13 | 0.10 | 0.16 |
| Sunset | 0.12 | 0.11 | 0.08 | 0.14 |

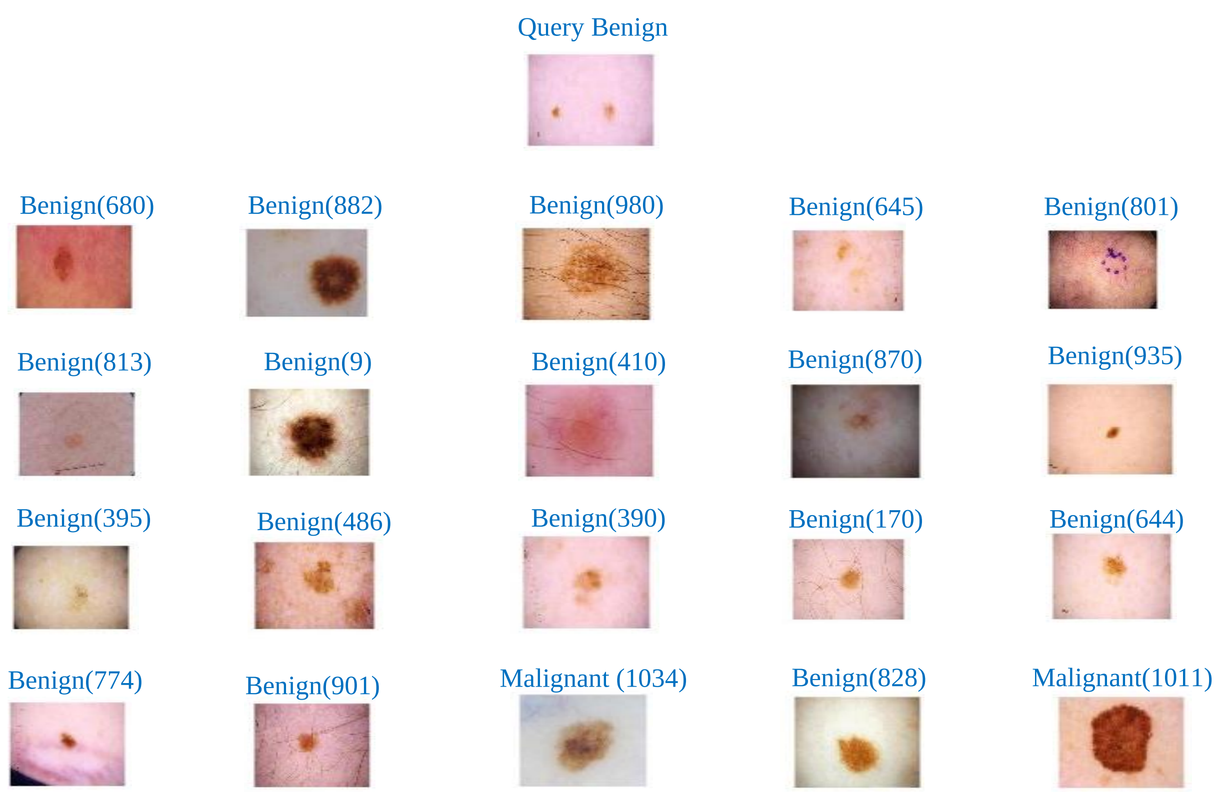


**Fig. 7 Benign skin cancer images retrieved by ACO-CBIR**

From these tables, it is observed that in most of the cases proposed ACO-CBIR system performs better. In a few cases it performs equally to the state of the art. These results encourage employing the proposed methods for a wide range of applications. Thus, the proposed system is used to detect skin cancer related images. The system is applied to retrieve images related to two major cancers of the skin: Benign and Malignant. The images are taken from [15], and each category has 1000 images. Once again the proposed ACO-CBIR system is compared with the state of the art mentioned in the paper.

Again, due to space, the graphical results of the proposed system are only presented. However, the numerical results are presented for all the methods. Figure 7 shows the results of Benign skin cancer and Figure 8 shows the results of Malignant. Table 4 shows the number of similar images retrieved. Table 5 and Table 6 show the Precision and Recall results, respectively. The tables from 4 to 6 show the better performance of the proposed ACO-CBIR system compared to other methods.

**Table 4. Retrieved images (20)**

| Images | EHD | CLD | KM | ACO-CBIR |
|---|---|---|---|---|
| Benign | 13 | 16 | 12 | 18 |
| Malignant | 10 | 15 | 11 | 16 |

**Table 5. Precision results (20)**

| Images | EHD | CLD | KM | ACO-CBIR |
|---|---|---|---|---|
| Benign | 0.65 | 0.80 | 0.60 | 0.90 |
| Malignant | 0.50 | 0.75 | 0.55 | 0.80 |

**Table 6. Recall results (20)**

| Images | EHD | CLD | KM | ACO-CBIR |
|---|---|---|---|---|
| Benign | 0.013 | 0.016 | 0.012 | 0.018 |
| Malignant | 0.010 | 0.015 | 0.011 | 0.016 |

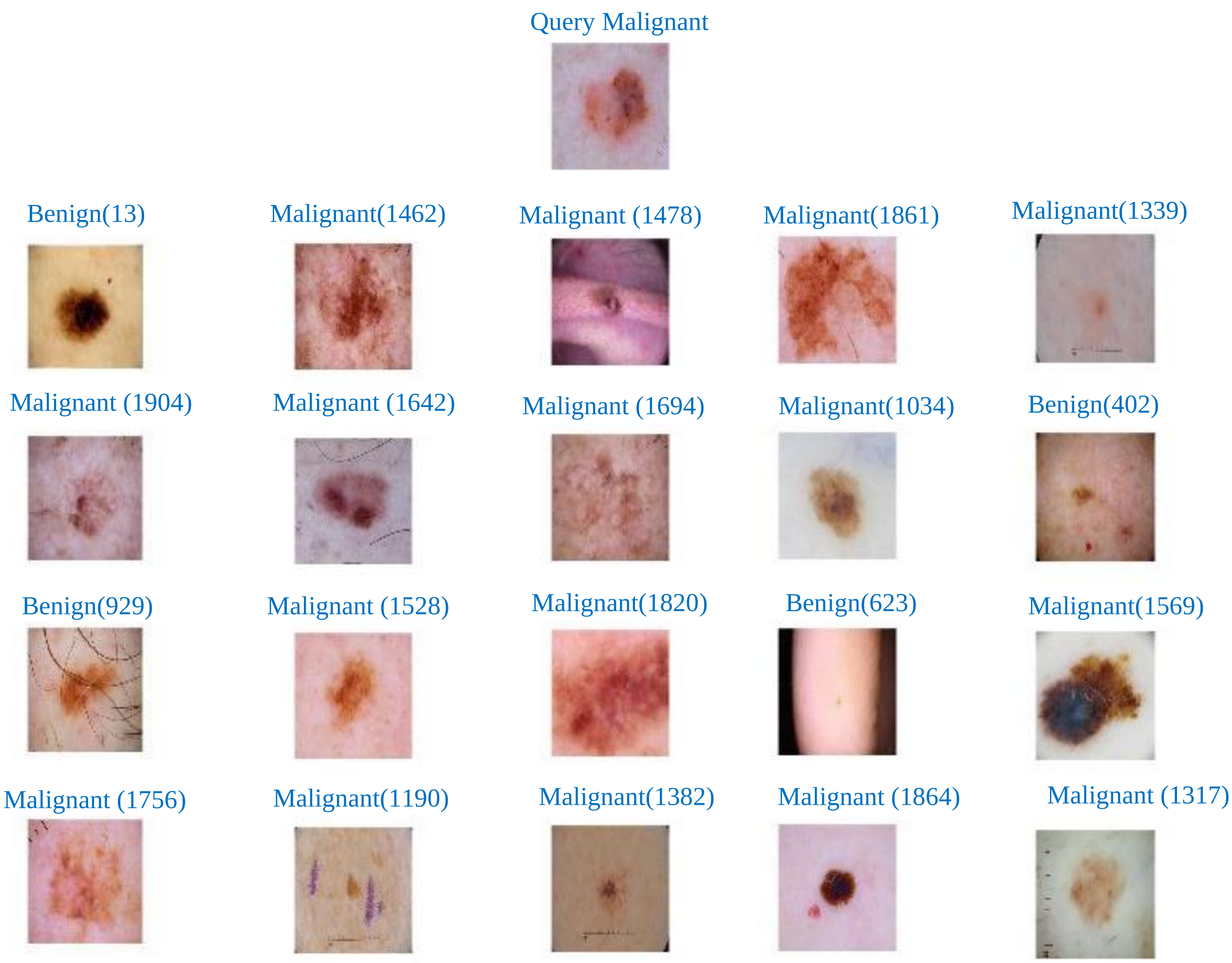


**Fig. 8 Malignant skin cancer images retrieved by ACO-CBIR**

## 6. Conclusion

Skin cancer has become one of the major issues in the health sector. The pre-diagnosis of this cancer may save lives. Due to the availability of digital methods, a new domain for diagnosis using images and related methods has emerged. One of the known methods is the CBIR system. This finds images in the dataset which match the given image. The CBIR searches the images based on their content. The key aspect of this system is image feature extraction. From the literature, it is seen that the ACO algorithm does well for image feature extraction. Hence, the capability of ACO is integrated with the CBIR system for image retrieval. Thus, the proposed method is called the ACO-CBIR system. The proposed system was first applied to general images and then to skin cancer images. It is found that ACO-CBIR performs better compared to state of the art and it detects skin cancer effectively. Since the ACO algorithm is nature inspired and proved to be an alternative in multimodal environment. The major contribution to good efficiency in the proposed system comes from the ACO algorithm.

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