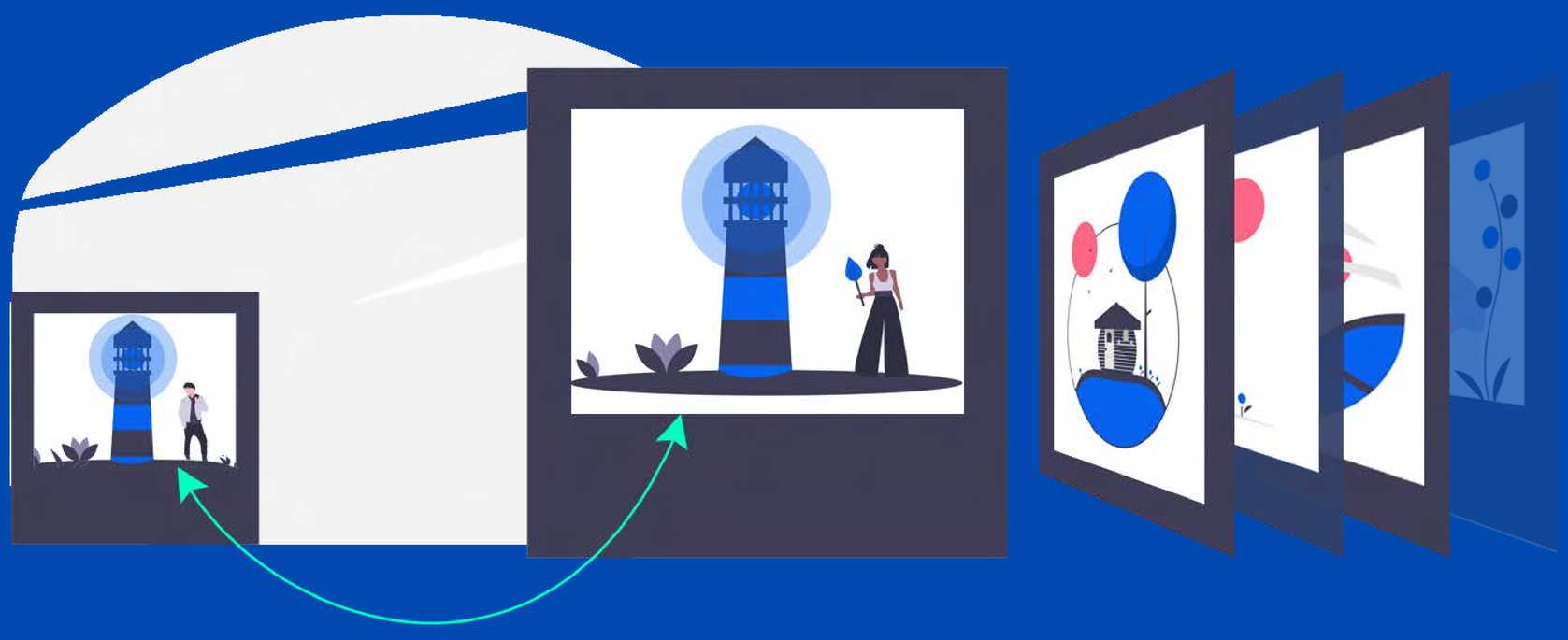
Your images mean a lot

LTU

White paper

Images functionnalities by LTU

Analysis, Search and Comparison



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1. Introduction

LTU, is a Paris based software publisher specializing in visual recognition. Their suite of tools provides an innovative mechanism which will analyze and define an image by assigning it a unique “signature” or “fingerprint”. This code enables their proprietary algorithms to detect and identify any images which are identical or a close match within a prescribed dataset.

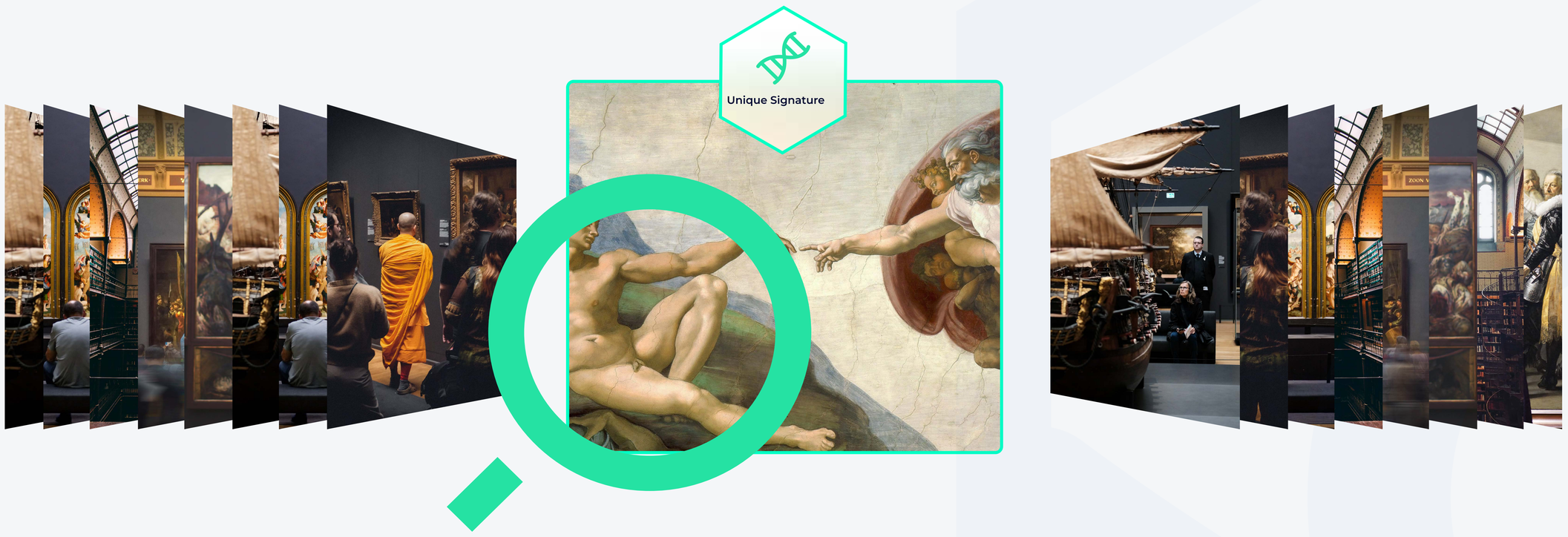
The performance of this patented technology is stand-out in the competitive world of image recognition. It has been optimised to allow the user to index a private database of million of images on a standard server, which will then return search results in a matter of milliseconds.

All the relevant functionality is packaged into the LTU Engine – the heart of the product driving all aspects of visual search applications including JSON API and a user-friendly interface. This document outlines each element of the technology provided and used in LTU products.

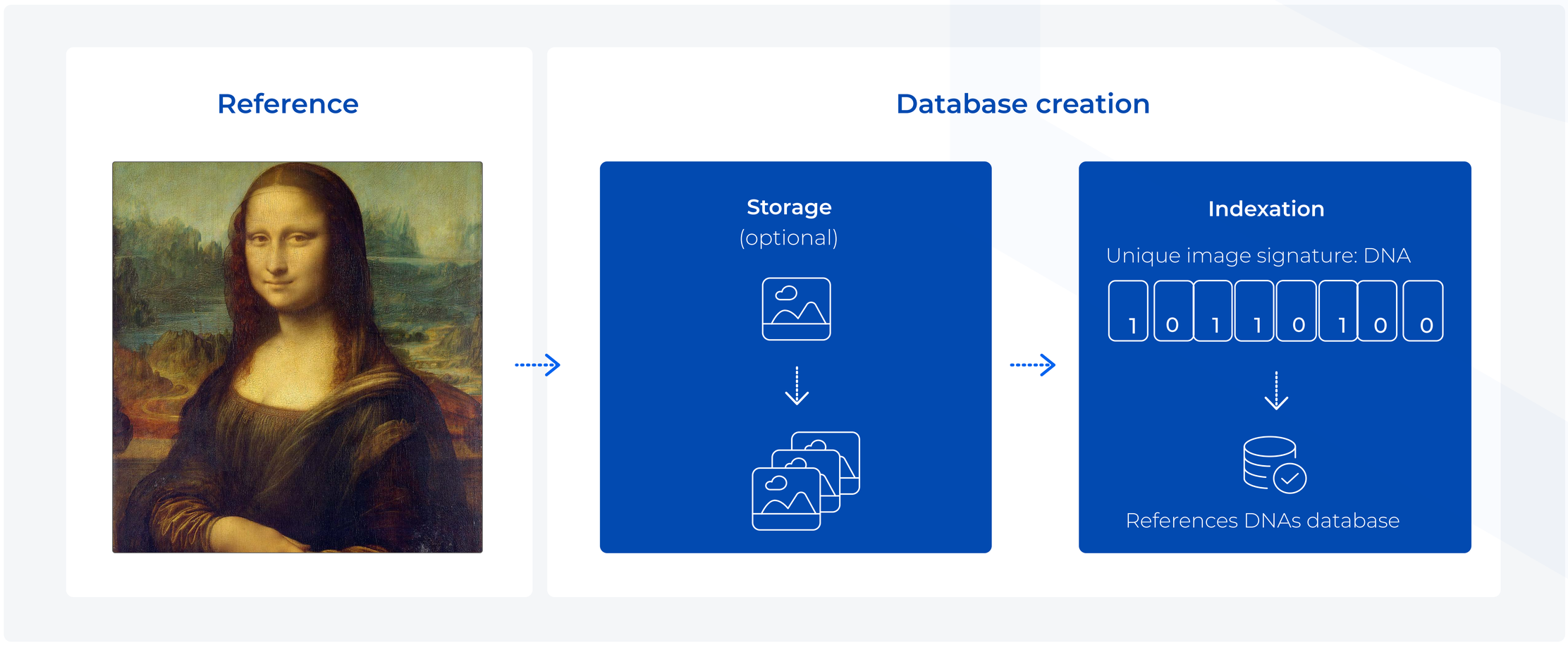
LTU technology is available either as licensed software or via a hosted platform. In cases where security is paramount, the user can choose to deploy the tools on their own servers, or more commonly to use LTU’s Cloud service which removes the need for hardware purchase and manual software updates.

2. LTU’s unique signature

LTU’s algorithms are specifically designed to analyze the visual characteristics of an image or object. These tools are not aiming to classify an item by typology, so the system does not need to learn that a specific shape represents a tree, or a face, rather it is designed to describe items by a series of objective geometric characteristics (patterns, curves, opacity, color, texture and a variety of other metadata). These measurements make up the visual description of an image and form the unique “signature” code. Every image will have a different set of characteristics made up of at least fifteen attributes, and which are combined to create a coded “signature” uniquely identifiable within the LTU system.



Also, the first step toward making an image searchable is to create the signature of the image content. LTU Engine computes a visual signature for every reference images and store them in a private database, in which you would make search by using LTU query retriaval solution. LTU Engine is fully optimized to let you index million of images.



These signatures can also be described as the ‘DNA’ of images. They allow the tool to identify an image with the reliability of a fingerprint, or DNA. Depending on the end-use case, LTU can tailor the way in which LTU Engine creates the signature code in order to optimize both effectiveness and efficiency.

Visual Recognition driven by ‘image signature’ protocols has a range of clear benefits:

- **A single source image is enough:** the technology does not require multiple reference versions of an image in order to recognize it with certainty.
- **The model does not need training:** no learning time required.
- **No transfer learning :** The model is robust, regardless of the typology of the reference images.
- **Data confidentiality:** LTU does not need to use the content of your images to train and improve its algorithms.
- **Energy saving:** Far less demanding in computing power than equivalent solutions based on Deep Learning; LTU technology’s approach leaves a significantly lower energy footprint.

3. Image recognition

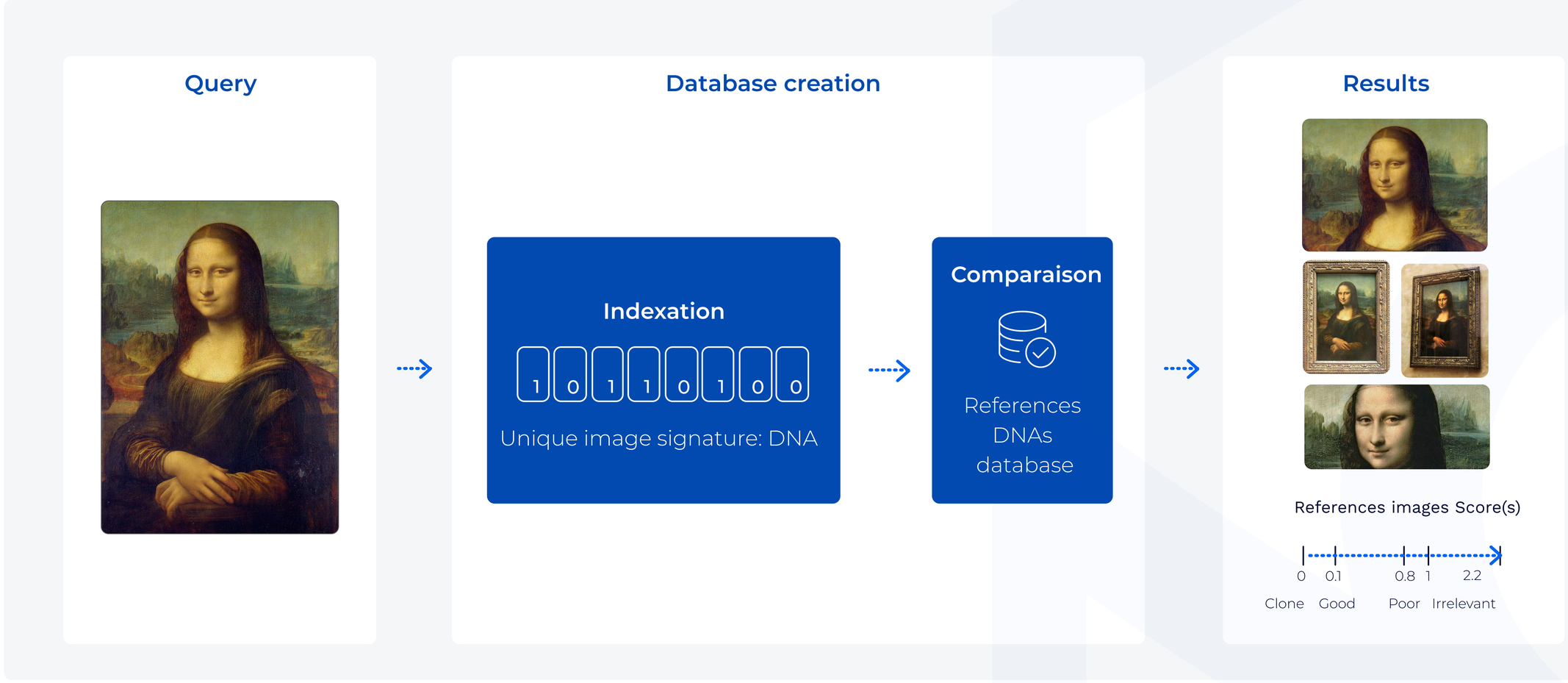
Using this unique image DNA technology, the LTU image recognition algorithm will interrogate the target dataset and find the images with the closest visual similarity. These will be ranked according to how accurately they match the ‘search’ image. LTU Engine offers three different approaches to image recognition:

- **Image Matching**, retrieves identical or partially identical images
- **Visual Similarity**, searches images that look alike
- **Color Search**, finds images with the same dominant color palatte

All the reverse image searches - outlined in this section - require an image references database.

3.1. Visual search solution

A visual search solution - brings back search returns from the target database which are identical, or identical in part, to the original query image. The search is based entirely on the content of the original image, comparing shapes, colors, and patterns which form its ‘signature’, returning results when it finds images on the database whose ‘signatures’ have characteristics in common. For a database containing 1 million assets, the average search return takes 300 milliseconds.



The visual search is composed by two key steps:

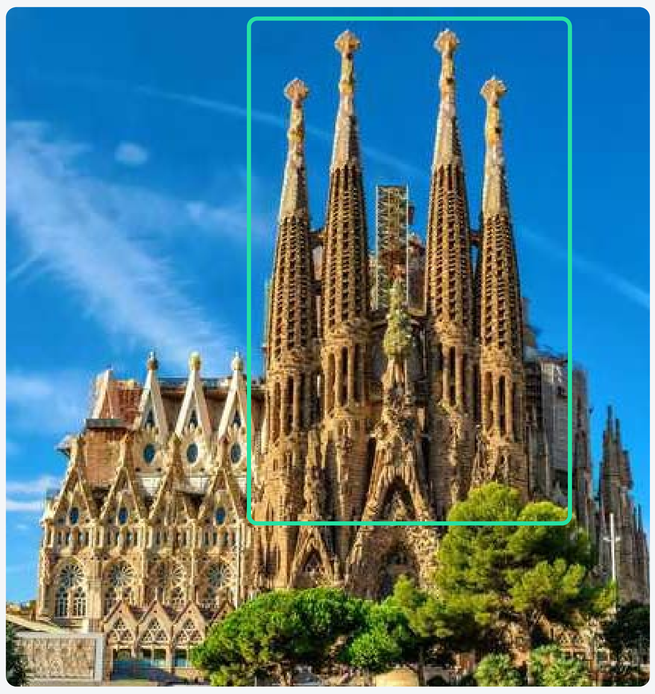
- **Indexation**: The creation of a descriptor of the content of the query image. LTU Engine computes a unique image signature, describing in code the visual make-up of every query-image in terms of its colors, shapes, textures other identifying patterns. These descriptors are also called image DNAs.
- **Retrivial**: A special comparison technology by which an image signature can be compared at extremely high speed with other image signatures from a database up to million of images.

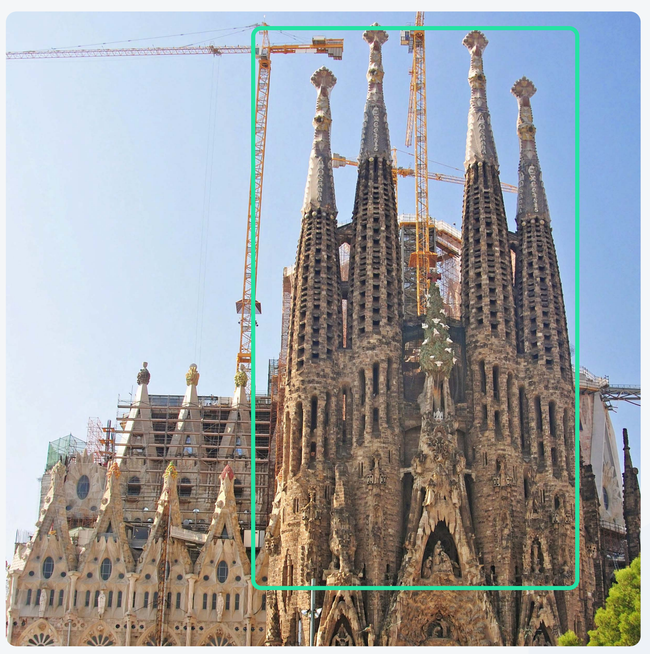
Each search returns a list of search matches, a measure of their similarity to the search image, as well as optional keywords and additional details.

Our clients used visual search for:

- **Art Identification:** checking whether art works are stolen
- **Brand Intelligence:** to survey if a product offer is compliant
- **Media Intelligence:** to analyze how a brand or product is represented on the internet
- **Place Detection:** to find a physical location from a picture
- **Display Identification:** to activate static advertising in print or on the street
- **And more ...**

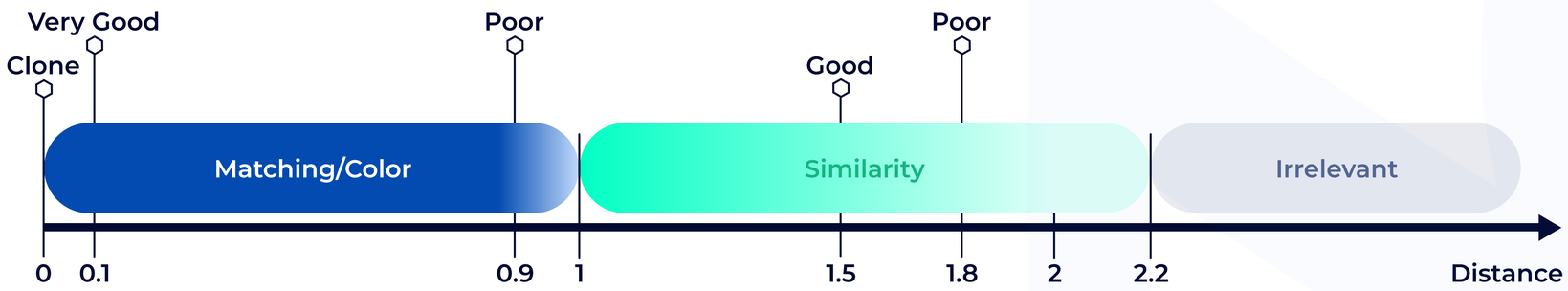
Image search





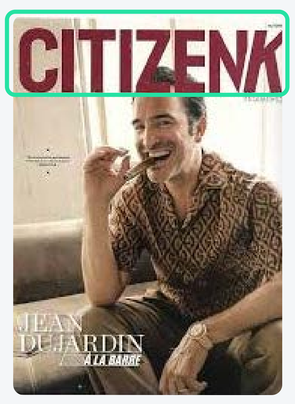
3.2. Visual distance

Visual distance is an indicator of the relevance of retrieved images: the closer the value is to 0.0, the closer the match – indicating that the retrieved image shares the same visual content as the query image.
The distance is normalized and qualifies the result of a match, color or similarity search.



The measure of visual distance is normalized such that a value:

- equal to 0 is a clone
- below 1.0 indicates a match or qualifies a color search
- between 1.0 and 1.8 reveals a similarity. The similarity distance is determined by a color and a shape score.



Score : 0.82

Score : 0.87

Score : 0.89

Score : 0.91

Score : 0.92

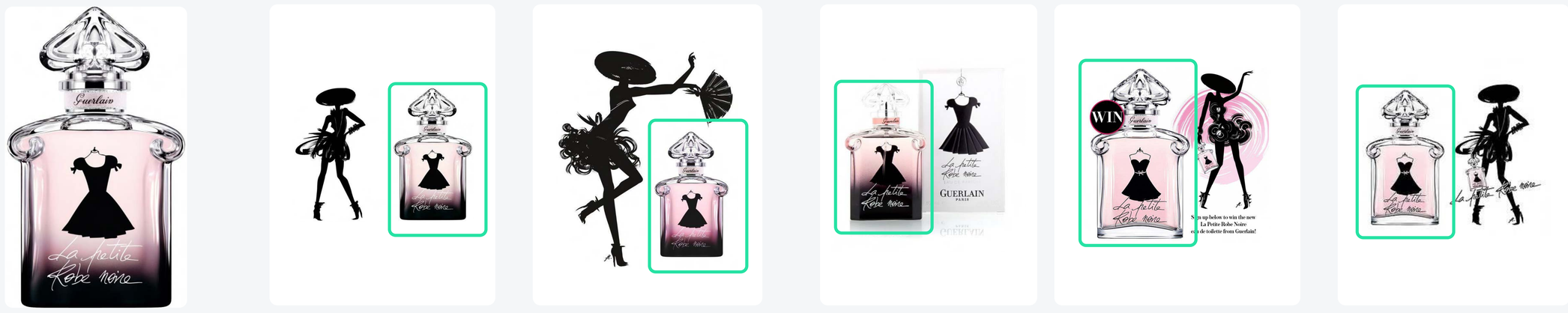
In the instance above, the distance score is high, reflecting the different cover images, but the results are correct as the tool was searching for the CitizenK branding.

3.3. Image Matching Technology

3.3.1. Overview

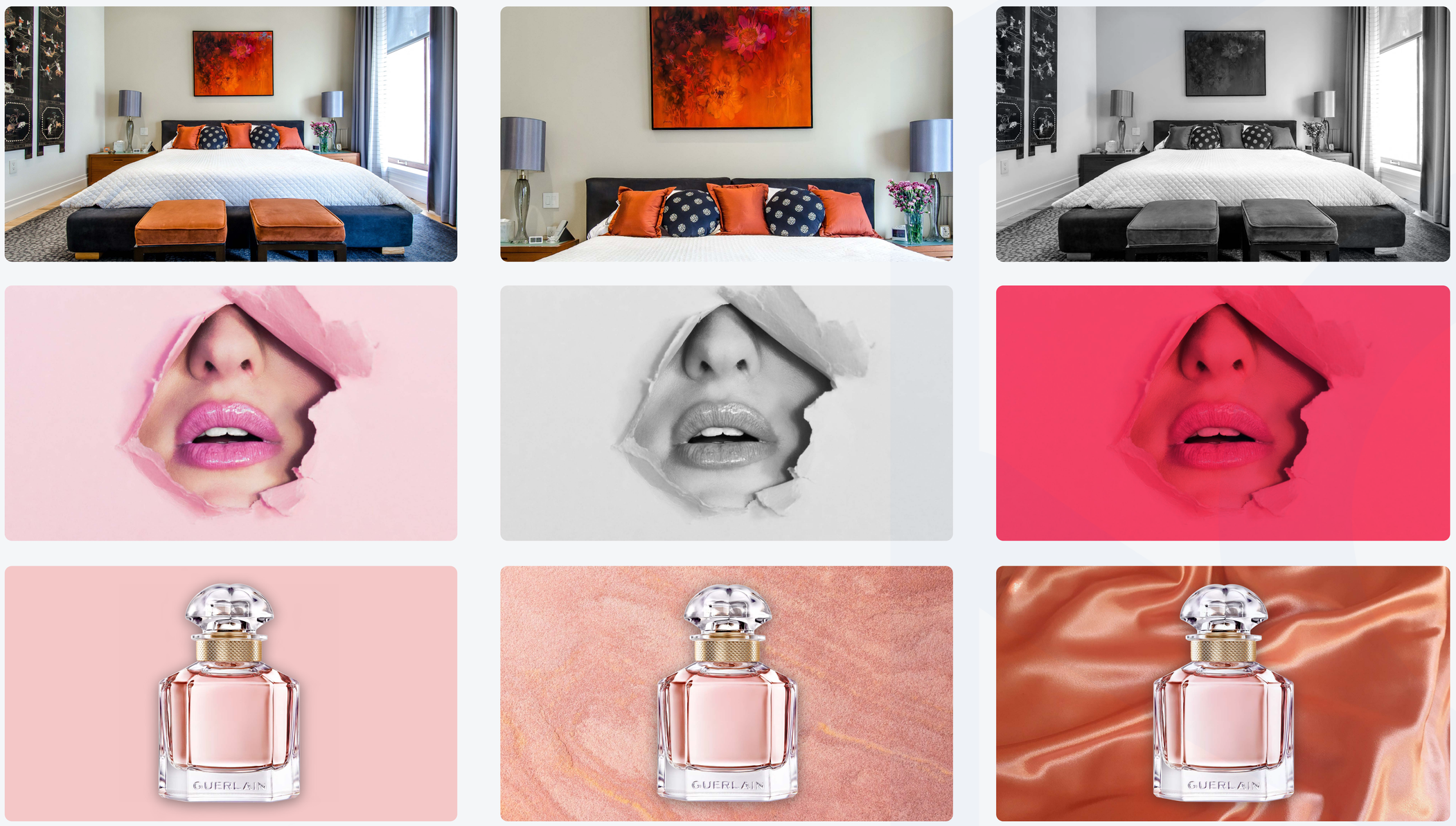
Image matching technology is used to find images in specified database(s) that:

- Look exactly the same (e.g. for deduplication)
- Have been edited in any way (e.g. for tracking on copyright images)
- Are photos taken of the same visual content (e.g. for print to mobile applications)



3.3.2. Image Transformations

LTU Engine’s image matching technology is robust against several types of image transformations, detecting not only the exact same image, but also modified versions of the original image and object matches (photographs of same object).



The types of image transformation that LTU Engine can handle in order to identify a match, include but are not limited to:

- **Geometric transformations:** changes in scale, rotations, translations, flips and projective transformations.
- **Photometric transformations:** color space conversions, gray level transformations, changes in hue, brightness and contrast.
- **Filtering effects:** changes in noise, smoothing, blur and sharpening
- **Structural transformations:** I composite images, (images that have been overlaid on top of each other), overlay of text, adding of borders and cropping.
- **Recompression:** Due to different compression algorithms (such as jpg) and different image encodings, information can get lost and artifacts may appear.
- Images derived from mobile devices

LTU image matching technology is robust even in instances where images have been subjected to a combination of the above transformations. The system easily matched the above combination which includes gray scale, blur, re-encoding, projective transformation and overlay composite transformations.

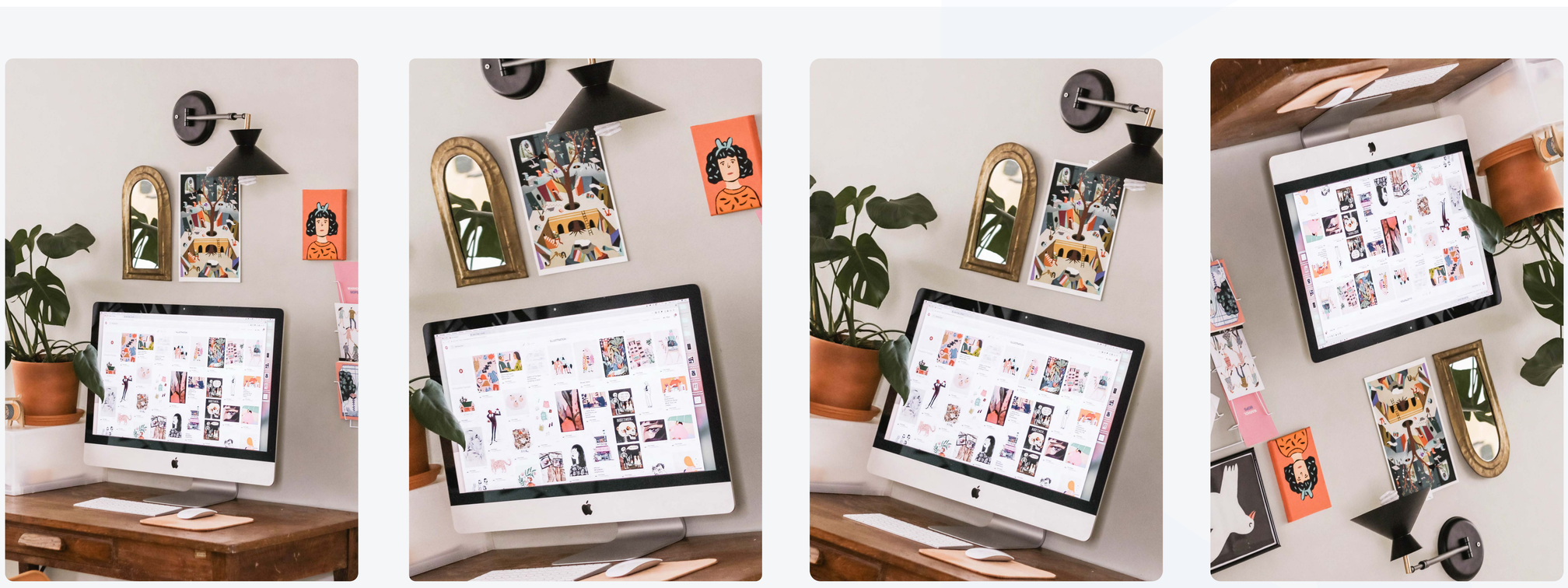
3.3.2.1. Geometric Transformations

LTU Engine is capable of identifying images matches regardless of geometric distortions.

- **Resizing of the original image**

Original | Resized | Resized, small changes in aspect ratio

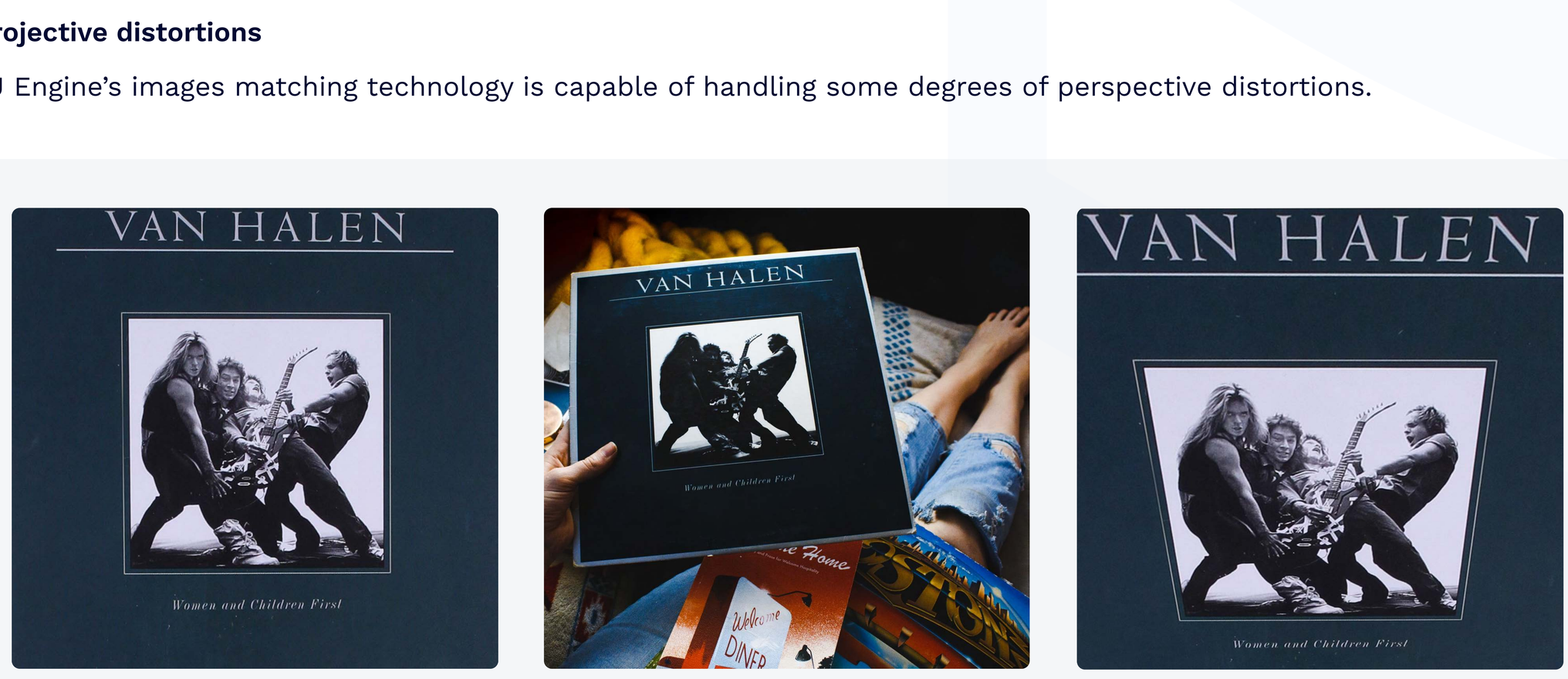
- **Arbitrary Rotations**



Original | Rotation -37° | Rotation 12° | Rotation -150°

- **Projective distortions**

LTU Engine's images matching technology is capable of handling some degrees of perspective distortions.

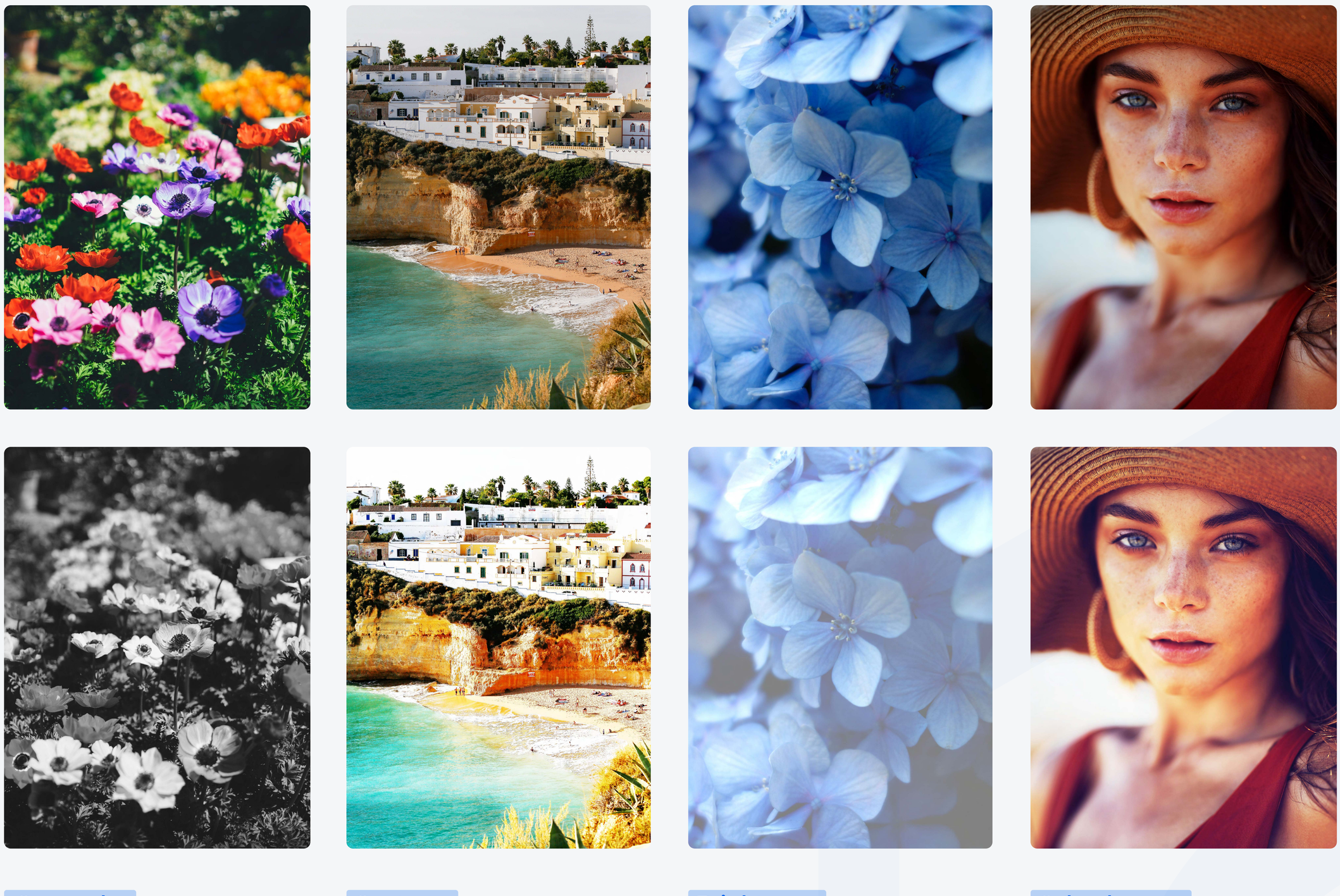


Original | Rotation negative | Rotation positive

3.3.2.2. Photometric Transformations

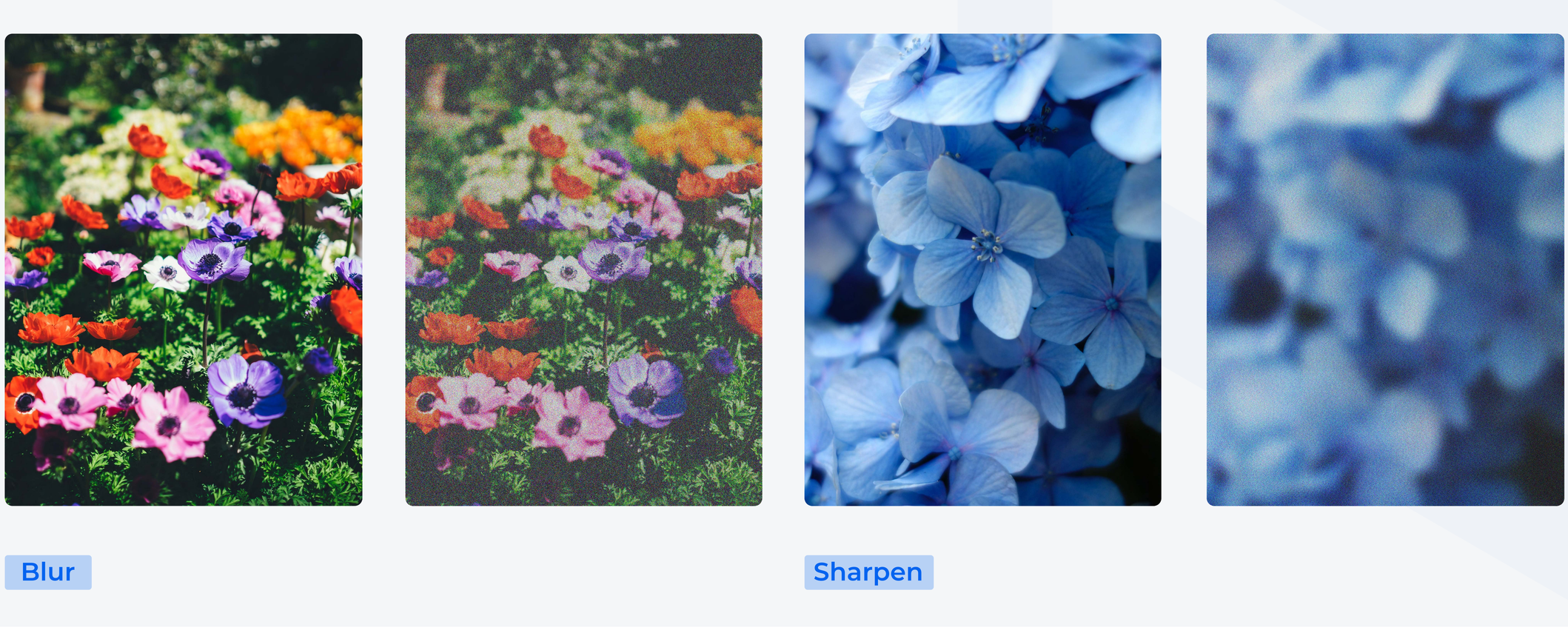
LTU Engine's Images matching technology can operate regardless of these photometric transformations:

- **Grayscale:** Colors image converted to shades of gray.
- **Brightness:** Luminance settings correspond to the degree of luminance (or 'sparkle')within each image pixel.
- **Contrast:** The difference between the darkest and the brightest parts of an image.
- **Color change (Hue):** Changes in coloration or hue achieved bay variations in the mix of the primary colors – Red, Blue and Green.



3.3.2.3. Image Filtering and Noise

Filtering effects are mainly linked with image printing, but also with modifying image metadata. Filtering transformations affect the image clarity. Depending on the filter used, they can either sharpen or blur the image. LTU Engine's images matching technology processes these images without difficulty.



3.3.2.4. Structural Transformations

Structural transformations affect the visual building blocks of the image. These transformations, however, do not limit the matching of images.

- **Framed, flipped, text added, cropped**

  Also, LTU Engine's images matching technology is capable of handling:

  - **Addition of a border or frame:** A border of uniform color is added on one, several, or all sides of the image.
  - **Flip:** Using a particular configuration of LTU Engine's images matching signature optimized for image tracking applications, the technology is capable of matching flipped images.
  - **Addition of text to the image/superimposition:** The addition of text to the image with or without a background. With LTU Engine's technology images are matched regardless of the addition of text.
  - **Cropped Images:** To cut out or trim unneeded portions of an image or a page. Image matching from LTU Engine handles cropped images without difficulty.

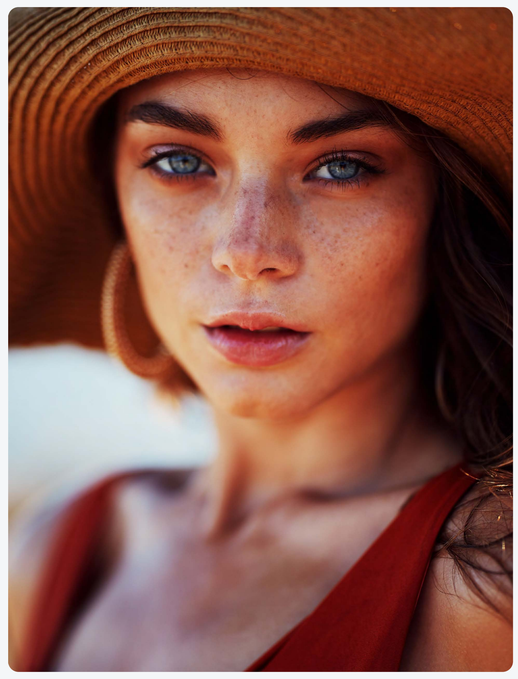
- **Composite Images**
  A composite image contains several photographs or graphics in one image and often has a modified background or added text. For this kind of transformation, LTU Engine's image matching technology delivers extremely accurate results.

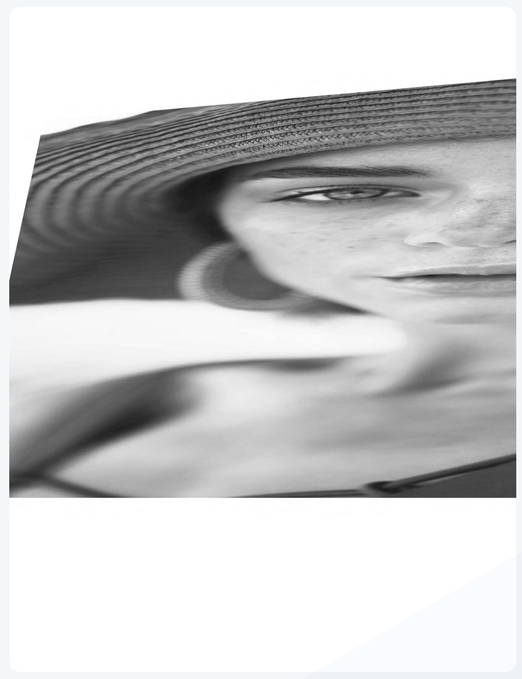
3.3.2.5. Compression and Image Encoding

In addition to the visually apparent image transformations detailed above, LTU engine is capable of detecting image clones even if the format or compression of the image has changed. Different image file formats include .bmp, .gif, .jpeg, .png.

Images are often saved in compressed file formats in order to facilitate faster downloading on the Internet. That compression alters the image slightly, but does not typically impact LTU engine's ability to identify a match.

Compression, grayscale





Combination of transformations

3.3.2.6. Images Derived from Mobile Devices

LTU Engine's images matching technology has been optimized to handle query images created with a mobile device.
Images shot on a mobile device can be subject to scale changes, motion blur, compression artifacts and they can have difficulties handling low-light situations. As a result, queries from mobile devices can be challenging to match. LTU Tech has developed an image matching signature that is particularly robust against combinations of these types of transformation. It is recommended, however, to avoid extensive glare, deep angled shots, very dark lighting and to frame the object of interest carefully.

References

Query

3.3.3. Matching Zone

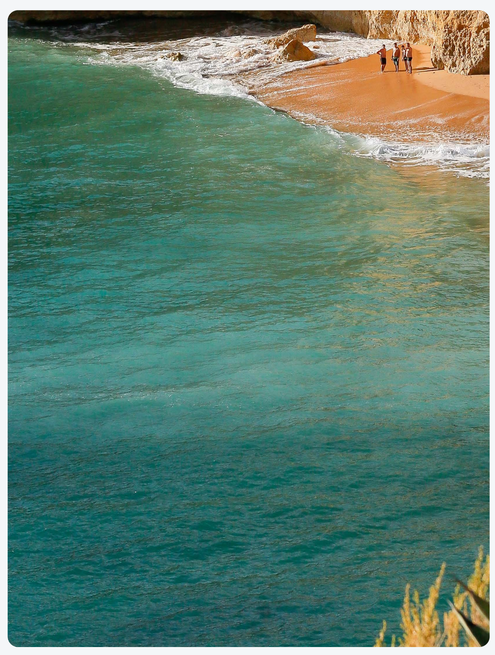
In addition providing a measure of visual distance, LTU Engine is able to return rich informations for any query. For example, LTU Engine can identify the areas of any target image which have formed a match with the query. This feature is useful:

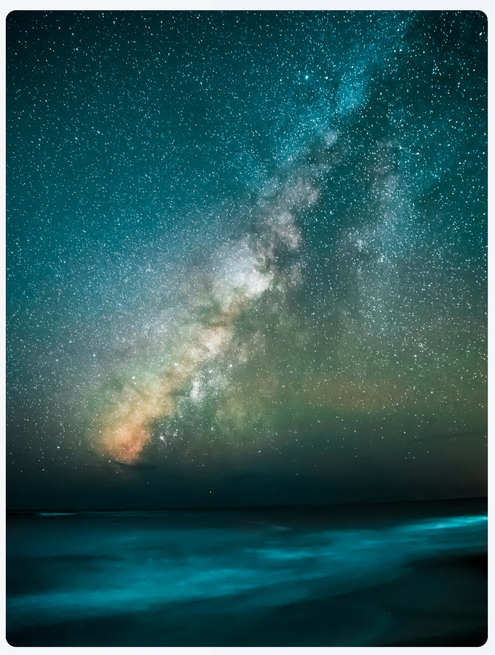
- to get visual feedback on the algorithm behavior
- to find the best custom filter option to achieve the most relevant results. Through a simple process of trial and error, the user can effectively begin to eliminate certain results from a search.

3.3.4. Limitations

3.3.4.1. Extreme modification of identifiable structures

The examples below present challenges for any images matching tool, due to intensive cropping specifically removing large areas of identifiable structures or patterns.





3.3.4.2. Repetive patern

Repetitive patterns with strong similarities can be particularly confusing for the tool.

3.3.4.3. False Positives

The rate of the false positives will depend largely on how the image matching technology is deployed within the end user's workflow.

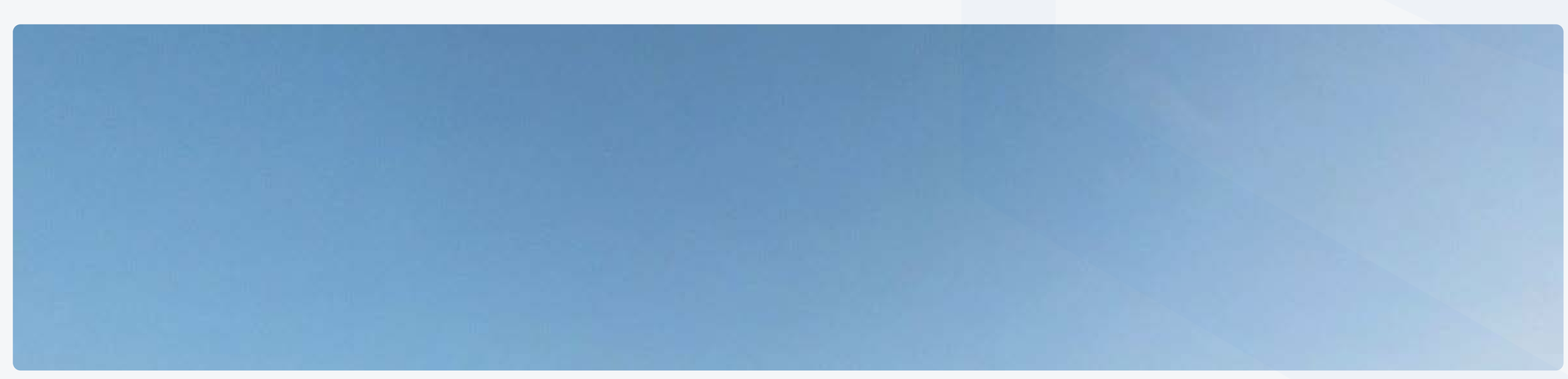
Since image matching is designed to detect any areas of identical patterning, small features such as logos or watermarks can result in what would appear to be false positives in the results. The tool, however, has actually recognised an accurate match.

Sometimes when two different images of the same object or scene share a high degree of similarity, the image matching algorithm will consider them a match. Technically these should be considered false positives, however in a workflow designed to identify images which share a high percentage of common features it is desirable to have these images included in the search results. This is especially true when the goal is to match photographs taken of objects – even more so when this is applied to mobile applications.

3.3.4.4. Indexing Limitations

Occasionally an image may not be indexed. This is due either to an unknown image format or due to missing image information:

- Uniform colored images are rejected.
- A lack of distinct image features, such as in the image below, will also result in rejection.



Finally images with dimensions less than 64×64 pixels are rejected in the default value of the LTU Engine (the default setting can be changed).

3.4. Similarity Search

3.4.1. Overview

LTU provides a solution for finding images that have a common visual theme. By submitting a query image, our technology can find images which contain a degree of similarity in the dominant color palette, the forms within the picture or a combination of the two. This is highly relevant for:

- automated solutions looking to recommend similar products for e-Commerce platforms
- creatives navigating extensive images libraries
- all areas of design where continuity of a color theme is essential
- investigators fine tuning a high volume of search returns.

The tool analyzes two characteristics: shapes and colors. These parts are independent and their scores are only merged at the end into the final score of the signature (between 1 and 2.2)

- **Shape:**
  Shape recognition is very powerful and the tool can find images with varying levels of similarity driven by the shape of objects within the picture. This means that if the query image features a prominent object that looks like a ball, the tool will retrieve other images with a spherical object as the main focus.
- **Texture:**
  On a finer level, the algorithm is able to detect the kind of texture used in the image. As a result, it is capable of identifying different paintings by the same artist, especially when they have a recognizable technique or brushstroke.
- **Color:**
  The color component of an image ‘signature’ is agnostic to any sense of scale, rotation or linear transformation. Color search is more flexible and can find images sharing the same broad color scheme. It also takes proportion of colors within the images into account.

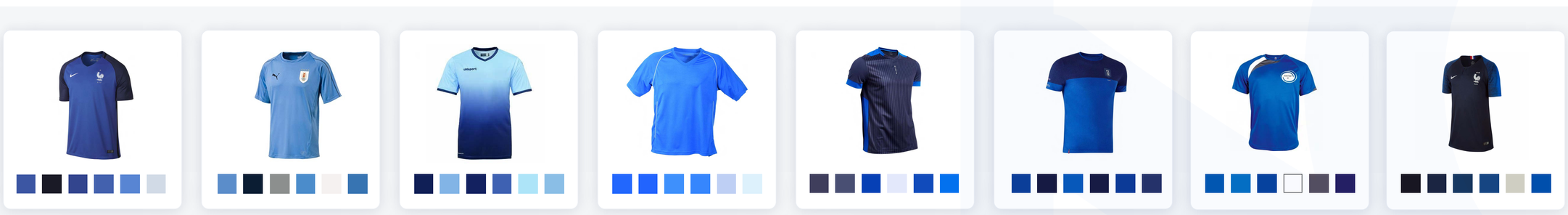
The relative importance of any color can be set at each query with a color weighting:

- **Color Weight 0:**
  If the color weight is zero, then the algorithm will only focus on the similar shapes.
- **Color Weight 100:**
  With a color weight at 100, the algorithm will only take colors into account when looking for similar images.
- **Color Weight 50:**
  An intermediate value between zero and one hundred indicates that both shapes and colors should be taken into account.

3.5. Color Search

3.5.1. Overview

In addition to image matching and similarity, LTU Engine provides LTU Color search.



LTU Engine Color is a powerful tool, analyzing the color make up of an image, allowing it to:

- Find the most popular color or color palette in a collection of images
- Identify all colors in an image or collection of images, by value and percentage

Color could also be a search criteria in its own right:

- Search for images by color(s) with optional color weighting (e.g. 25% red, 75% green)
- Upload an image to find images with similar colors

LTU Engine Color is able to analyze the content of images and automatically identify the all the colors present, unlike many existing color tools that require significant levels of human input and annotation. As the process is fully automatic, it is also very accurate. LTU Engine analyzes the colors that are actually present in the images not only a rough hue. This accuracy allows the user to look for very specific color tints within an image collection.

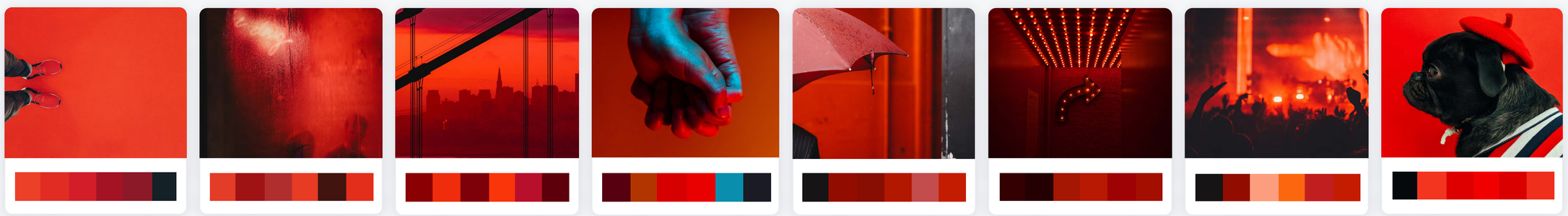
3.5.2. Queries

Once LTU Engine has indexed an image collection, it is possible to run queries on it. There are four kind of queries: get image colors, query by color, query by image, compute palette.

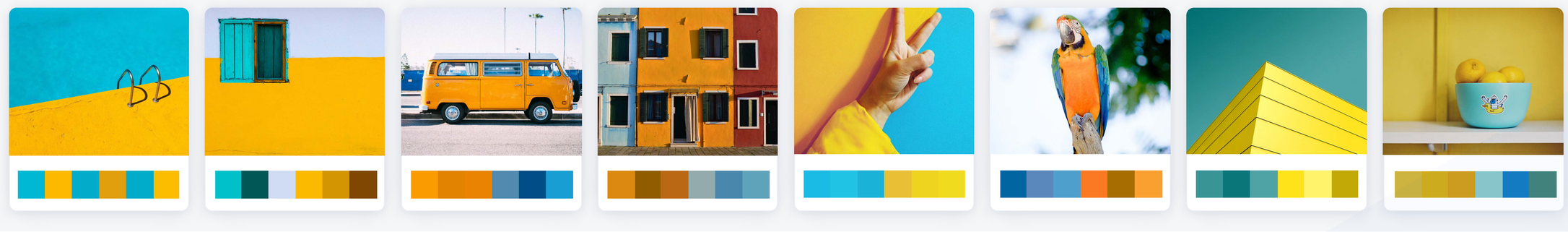
3.5.2.1. Query by color

With LTU Engine a user can search a collection of images based on color alone. For example, LTU Engine allows the user to run a color query such as, “pink” or “pink and green”. Search returns will then consist of images all featuring the desired colors. This list is sorted by relevance based on the dominance of the specified color. The LTU algorithm is both accurate in its ability to return very specific tints, and it is also very robust, returning the images with the required color tints at top positions ahead of slight variations on the original query.

Results for a query by color “red”:

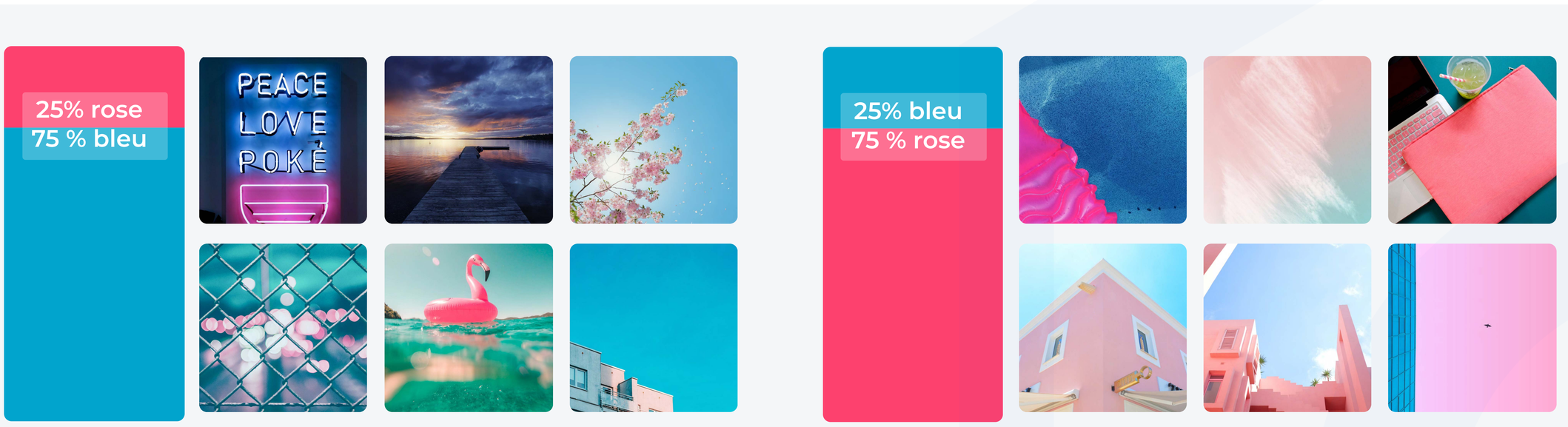


Results for a query by color “yellow and blue”:



With LTU Engine it is also possible to specify a desired color weighting. A user can run a query such as: ‘look for images with 75% blue and 25% red’.

Results for a query by color in varying proportions:



3.5.3.2. Query by image

Once a user has found a relevant image (using a query by color for example) they may want to find similar photos in the collection – at which point they can run a “query by image”.
Given an input image, query by image looks for images in your collection that have similar colors.

This feature is useful when:

- an image features a broad spectrum of colors
- the user does not know a specific color code

3.6 Search by keywords

LTU’s solution also allows the user to search an image collection by using one or a combination of keywords. The search is not just visual anymore, it is thematic. For example, that could help to find all the pictures of a photograph whose theme is “fruits”.

Lemon

Blueberry

Orange

Raspberry

Keywords can be assigned to each image in a database. Keywords can be attributed manually or be the result of a deep learning process. So, keywords can then be combined with a visual search process to restrict the query result to specific categories.

Results of a query by color “red with keyword ‘sofa’”:

4. Image analysis and processing

LTU Engine provides several algorithms -presented in this section – to allow the user to process and analyze their images. Image analysis can be a powerful complement to a visual search. These algorithms do not require an image database. The processing is done directly on the image itself.

4.1. Colors palette

4.1.1. Image colors

LTU Engine can identify and provide a list of colors that are present in an image.

4.1.2. Trends within an image collection

LTU Engine Color can analyze an entire images collection and identify the most frequently occurring colors; the colors palette of
the collection. The colors palette can be used to:

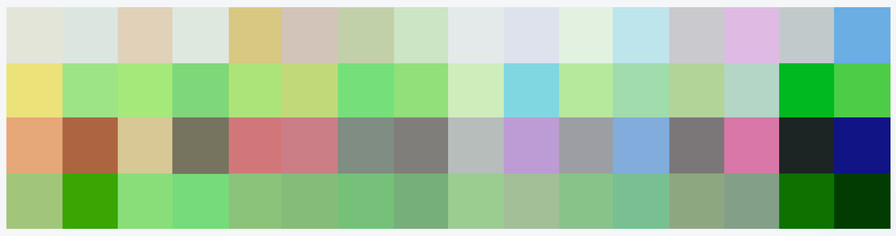
- suggest relevant queries to the user
- provide a quick overview on an images collection

An example use-case for palette analysis is in examining any subset of a collection.

For instance, subsets can be categories. LTU Engine can compute a palette for the “Women’s Shirt” category. This will provide a palette of predominant colors featured in women’s shirts, which can then be compared to the color palette of the collection as a whole.

These subsets can also be result sets. If they are used to propose queries to the user, this feature can be a powerful tool for query refinement.

Palette computed on full image collection

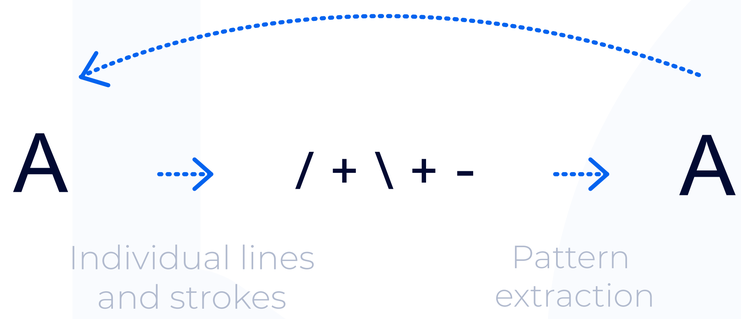


Palette computed on the results
of a query by color « green »

Palette computed on the results
of a query by color « purple »

4.2. Optical Character Recognition

Optical character recognition refers to both the technology and process of reading and converting typed, printed or handwritten characters into machine encoded text or a format that the computer can manipulate.



LTU used OCR solutions to extract text from an image. The retrieved information could help to :

- Classify images dataset
- Determine keywords

Logo

Vogue

OCR

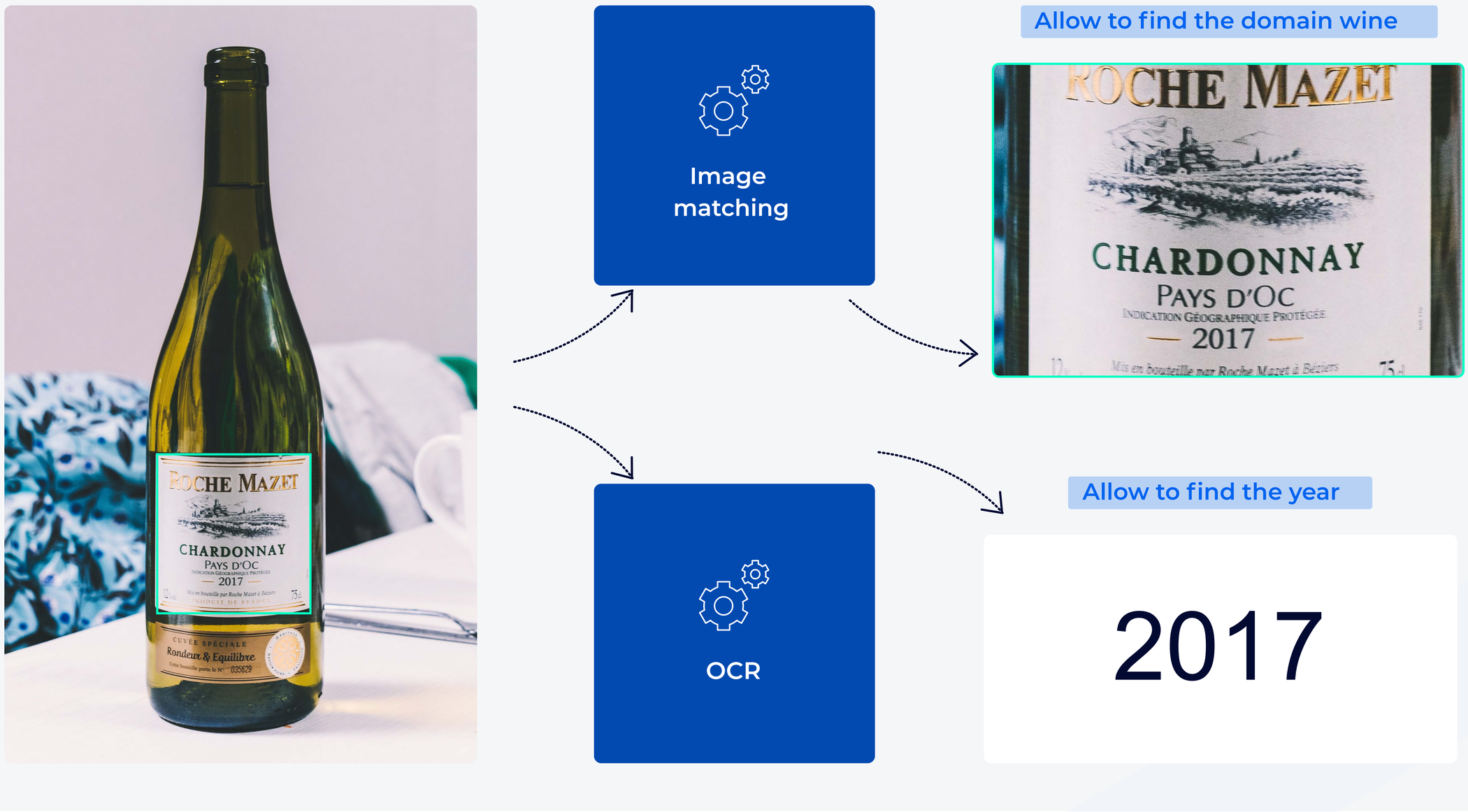
Rihanna / Fashion / Style / Paris

Colour Palette

Keywords

Women	Red	Paris
Rihanna	Fashion	Black

LTU can incorporate OCR algorithms to further refine images search results.



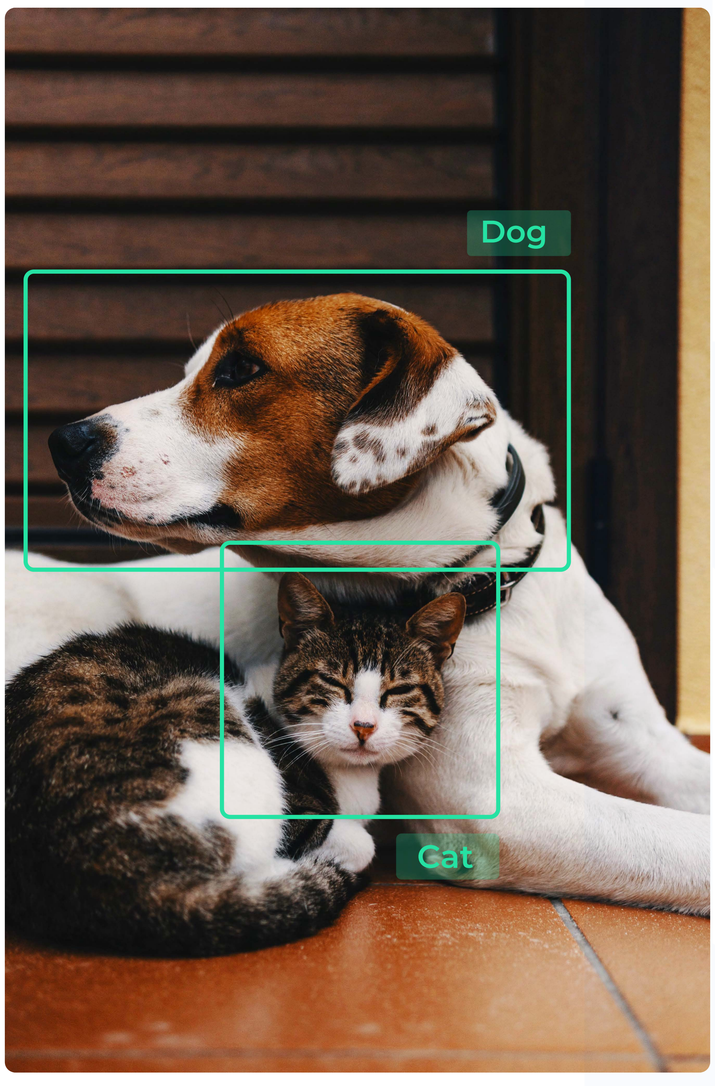
4.3. Keywords extraction

LTU technology can be linked with deep learning models to classify large batches of images, detect objects in an image and generate keywords.

4.3.1 Objects Identification

Image Classification is the task of taking an image as input and outputting a number of classification labels from a pre-determined set of classes, based on the subject matter of that image.

The process normally involves recognition of the dominant content in a scene. The dominant content will be allocated the strongest confidence score irrespective of any transformation of that content such as scaling, location or rotation.



Choose state-of-the-art Deep Learning algorithm :

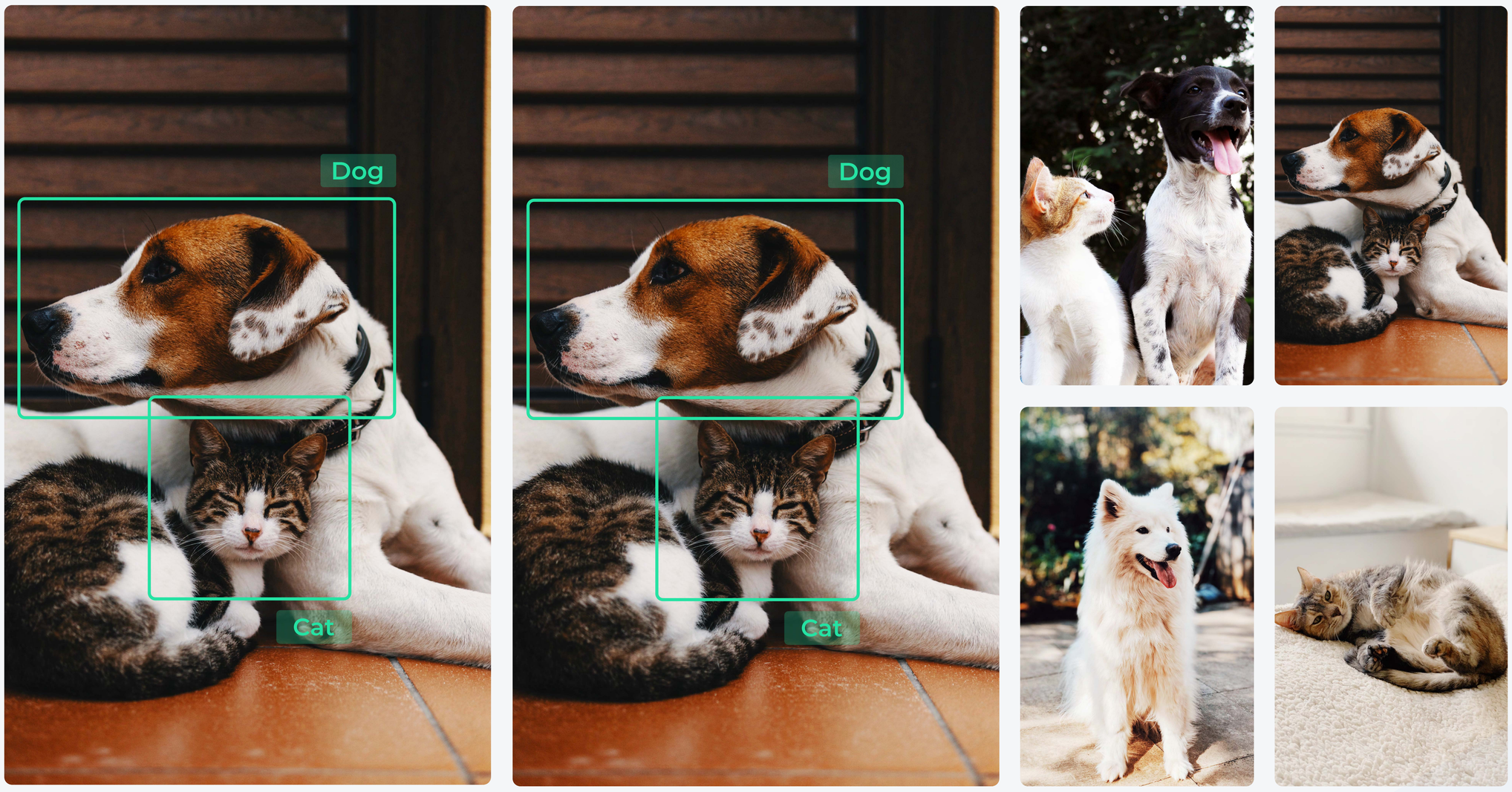
- Single Shot Detection (SSD)
- You Only Look Once (YOLO)
- Faster R-CNN
- ...

Train & Test

High Accuracy & Real-time Object detection

4.3.2.Keywords

As explained, Deep Learning helps LTU to classify your images in pre-trained classes. LTU also allows to associate these classes in keywords. Thus, Keywords will help to organize your dataset, to search images with keywords inside your dataset and to orient the image search process.



From output of object detection & classification

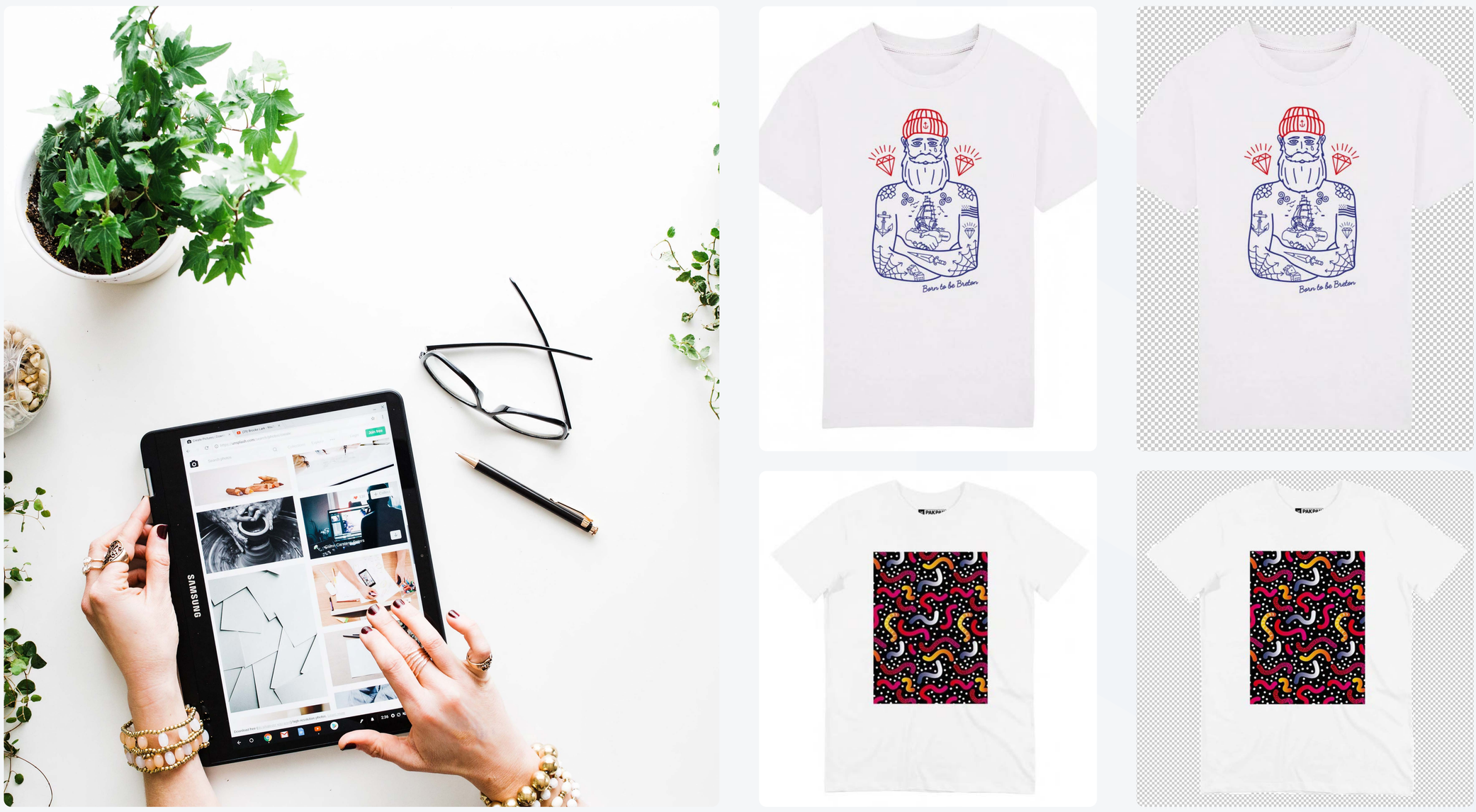
(Cat; Dog)

Label image using keywords from detected & classified objects

Cluster similar images in database based on keywords proximity

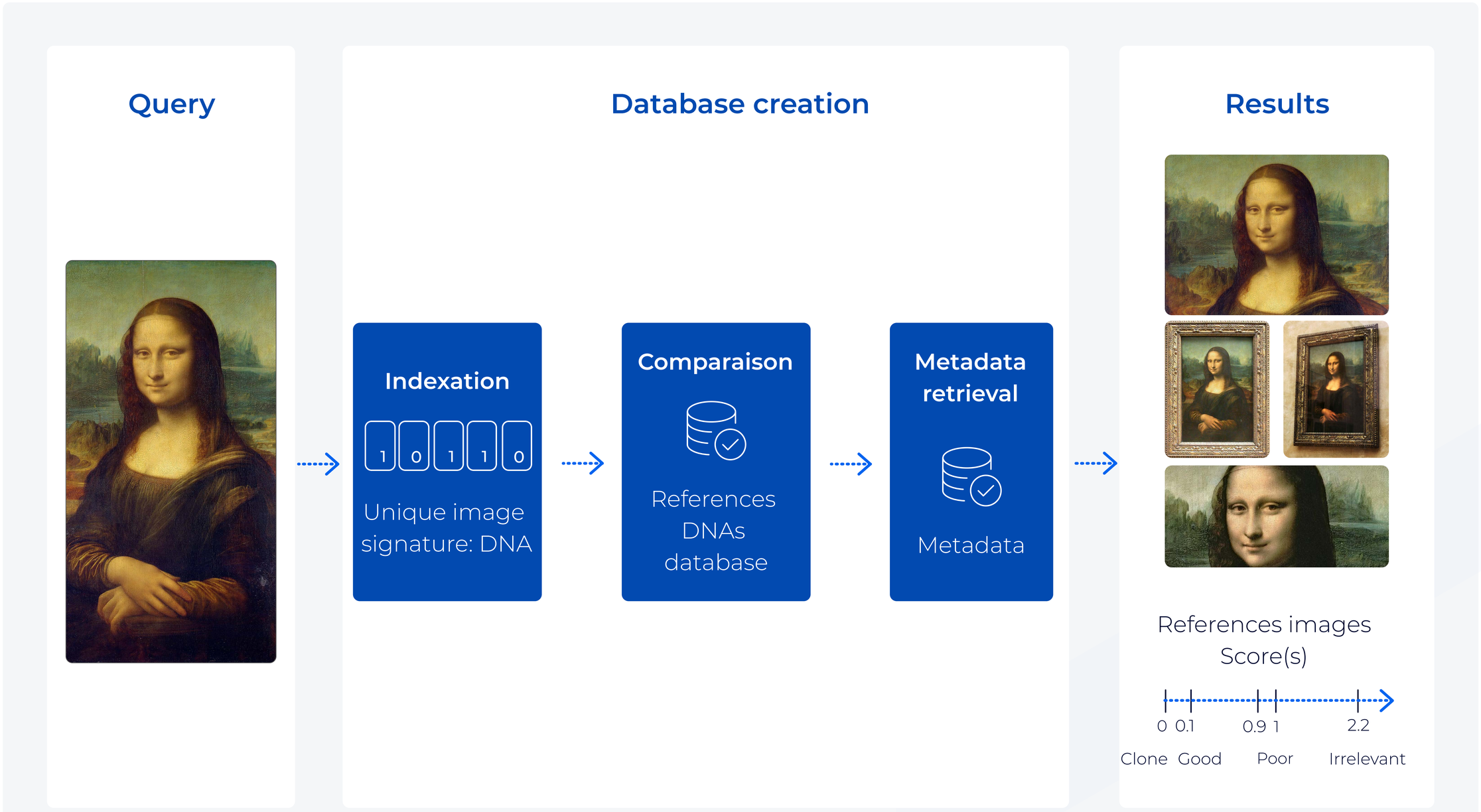
4.4 Uniform Background removal

By default, the image signature is computed on the whole image. For some specific cases, this behavior can be problematic. For instance, in e-Commerce products are often shown on a uniform background. Thus, the algorithm is likely to consider the background as the main color. To tackle this issue, LTU Engine introduces a background removal algorithm that identifies uniform backgrounds and computes the signature only on the foreground image. If no uniform background is detected the signature is computed on the whole image.



5. Link images with Metadata

LTU offers the user the ability to associate metadata to their images. Thus, once an image is identified, the user can access all the data stored with it. Linked data also allows connections to be made between images that may not be immediately visually related. Metadata is saved in a separated database.



6. Changes detection

The changes detection is a specialized technology especially pertinent to media intelligence applications.

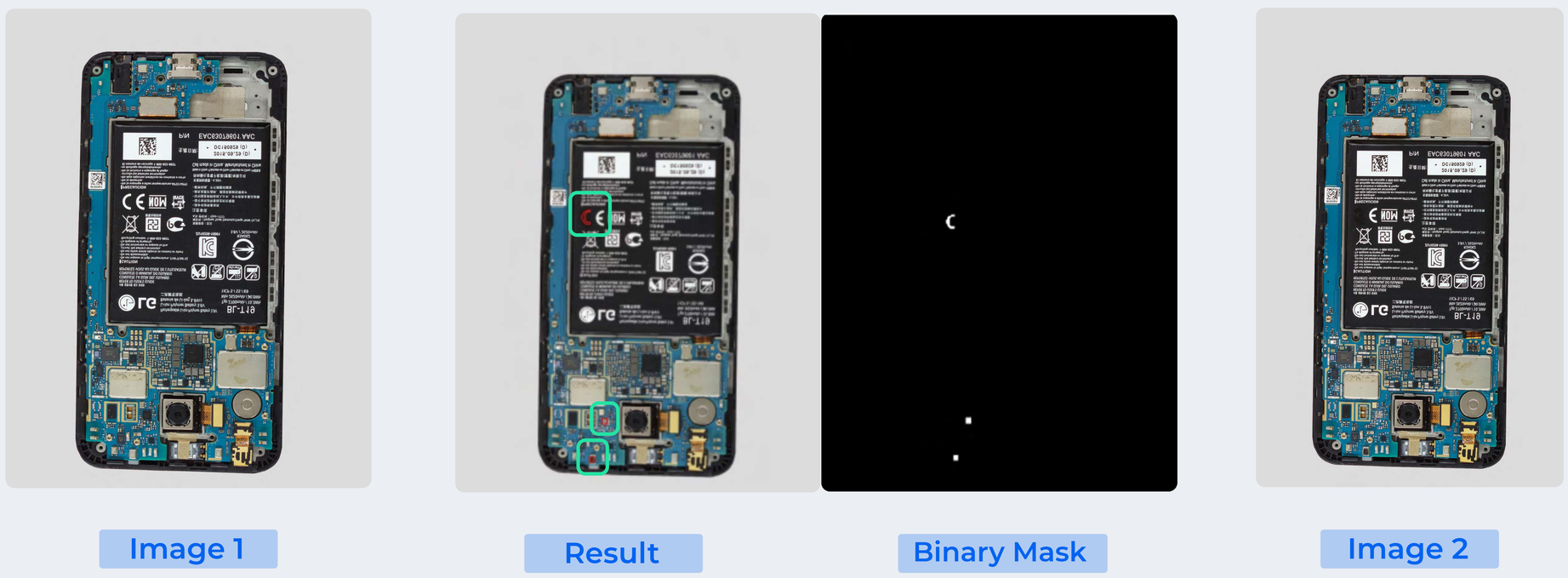
Change detection is designed to:

- automate the comparison of images which largely match but which may contain subtle differences
- provide additional details on the results of matches. The fine image comparison feature provides visual feedbacks about matched images including a visual highlight showing where differences are located.

The changes detection process generates the following elements:

- **score**: a score is generated which quantifies the visual distance between the two images
- A list describing the positions and the delimitations of the changes.

The examples below are typical of the types of images to which Fine Image Comparison is applied:



Changes Detection is also a useful tool in comparing original and counterfeit packaging.

Reference

Query

Changes Detection could also compare satellite images.
Indeed based on the comparison feature, LTU has developed Earth Change. EarthChange is a processing pipeline dedicated to changes detection in remote sensing images aiming at providing users with accurate informations on surface changes for environment and urban monitoring, damage assessment and intelligence.

Usecase: detection of burnt land

Image T1

Image T2

Result

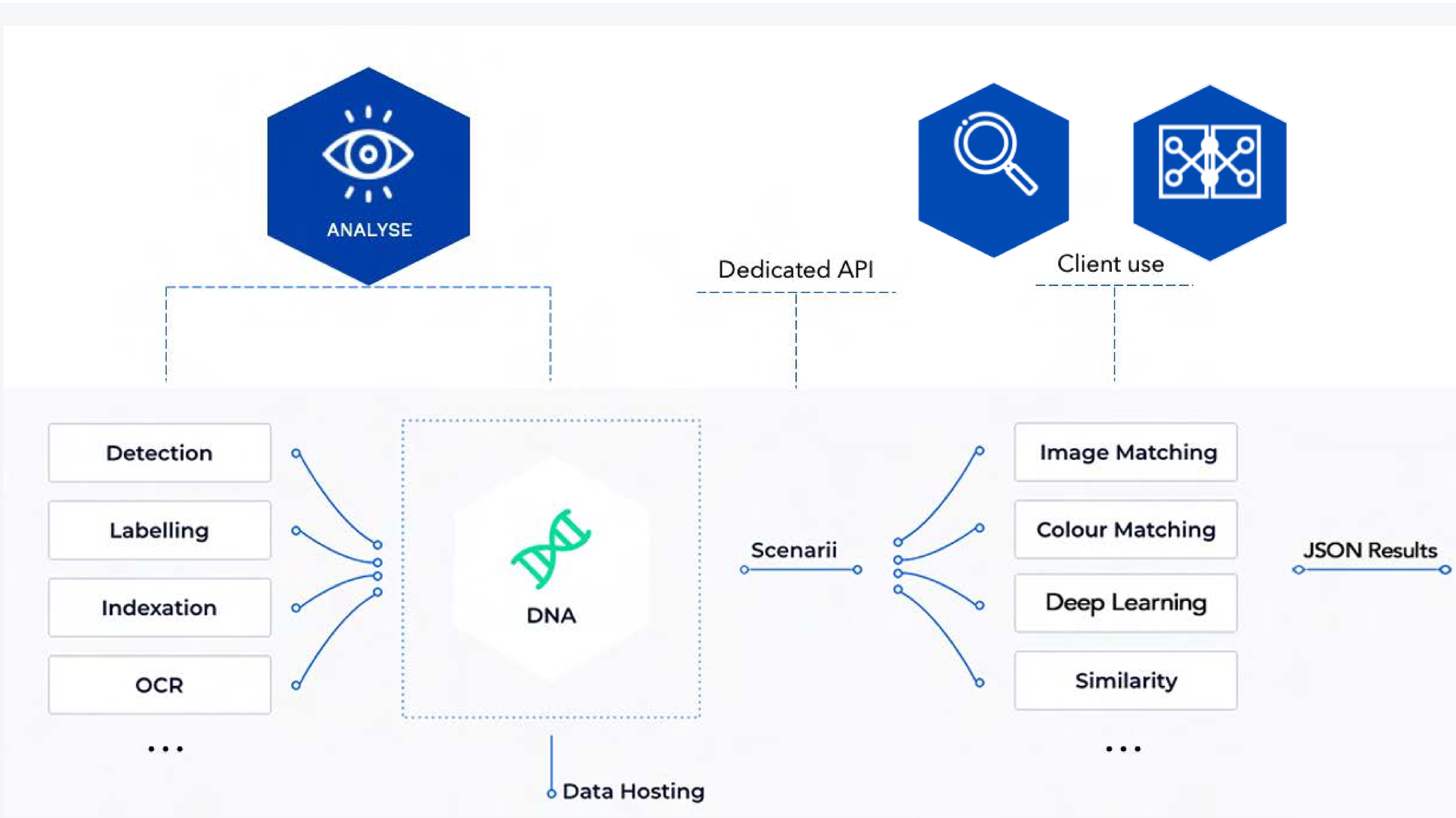
In a media intelligence application, Changes detection could be used in conjunction with LTU image matching.

- Unidentified advertisements are compared with a database of know advertisements.
- Certain ads are identified as definite matches.
- Cther ads are identified as possible matches, but which need validation (their matching scores may indicate the possibility of variations).
- Changes Detection is applied to the pairs of possible matches. The score generated by the Changes Detection tool determines whether the possible matches should be classified as ‘definite’ or should be examined in a human validation process.

7. Conclusion

LTU Engine creates a complete, flexible and configurable solution to provide users with highly effective analysis, search, processing and comparison of their entire image database, regardless of volume. The unique combination of proprietary algorithms developed by LTU means that their tools are specifically designed to solve problems encountered in real world scenarios.

ln this last part, we describe an example of an external solution that could be combined to LTU's algorithms.



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