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Automated Medicinal and Aromatic Plants Using GIS (with a Preconceived Knowledge)

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ABSTRACT

This research aims to redirect the functionality of ArcMap, is a software from the group of Geographic Information Systems (GIS), for automating medicinal and aromatic plants. This application gives the ability to identify a plant, directly in the field with a preconceived knowledge. Of course, this knowledge will be done after the completion of the automating of the plants in this application. If a researcher or interested in medicinal and aromatic plants wants to know some information about a plant, suggested system should enter plant specific "keywords" within it. These keywords will eventually lead him to know the scientific name of the plant and, all its medicinal and aromatic properties that have been previously programmed within the application tables. In addition, he can know the location and coordinates of this plant in the region or even at the level of the country. In the future, this application can be generalized to include the biodiversity in general, such as *flora* and *fauna*. It is a qualitative achievement, as this product will provide a great service to all interested amateurs, researchers, universities and institutes students in the fields of pharmacy, natural sciences, agricultural and wildlife, and even for ordinary people.

1. Introduction

To date, the total estimated number of species on Earth is about 8.7 million (more or less 1.3 million)—the most accurate calculation ever made—with 6.5 million species on land and 2.2 million in the oceans [1]. Scientists have counted the currently known, described, and accepted number of plant species at 374,000, of which approximately 308,312 are vascular plants, [2] with 295,383 flowering plants (angiosperms; monocots: 74,273; dicots: 210,008) [3]. Scientists estimate that there are about 3,227 species of medicinal and aromatic plants belonging to 235 different plant families [4]. The most commonly recognized forms of agriculture were agroforestry, intensive agriculture, and controlled agriculture, followed to a much lesser extent by intensive agriculture and natural care. Of the species recognized, 954 have an International Union for Conservation of Nature (IUCN) genus name. As for us as ordinary people or even as researchers, how many types of these medicinal and aromatic plants do we know? The desire to learn and know the nature of living organisms around us is an innate instinct in humans, especially with regard to plants of all types and forms found on our planet Earth. Whenever we walk in a garden or go on a trip to a forest, we always have a feeling of knowing the name of this or that plant, especially those plants with beautiful flowers and fragrant smell, and what are their medical or nutritional benefits in our daily lives. We may know the names and benefits of some of these plants, but we certainly do not know the names and benefits of many of them due to the huge diversity of their types and varieties. Although these plants are sources of most of the vitamins our bodies need, they are also excellent food sources in addition to being the primary producer of medical and pharmaceutical drugs and extracting the finest types of natural perfumes, or to avoid poison from them. However, humans still do not know the names and properties of most of these plants. Historically, it is known that the method of identifying plant names in general and medicinal and aromatic plants in particular has gone through many stages, starting from the use of medical dictionaries and various classification books, to the use of computers and up to the present day where artificial intelligence techniques are used through smart digital cameras. Despite the technological progress in artificial intelligence methods, there are still difficulties to this day in quickly and directly identifying the name of the plant and its characteristics. In this research, we present a method and a tool for every ordinary

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person, amateur or researcher who can take this application with him on his outings in the forests or while walking in the fields, where he can use this application to quickly identify the name of the

plant and its characteristics when this application is completed and accomplished in a way, noting that this application does not cancel the benefits of previous methods, but rather it is complementary and complementary and provides a new and innovative scientific and technical benefit.

2. Reference Study

If we go back in time to see the evolution of the methods used to identify medicinal and aromatic plants throughout history, we find that they have gone through different stages. We can show this through the following narration: Traditional methods (papers): such as botanical classification books or dictionaries of medicinal and aromatic plants [5] and [6]. Using the computer: Researchers currently use the computer to link as many traits as possible associated with the plant, whether qualitative or quantitative traits, according to [7] and [8]. Then they calculate the taxonomic (or genetic) distance that separates each pair of taxonomic groups treated based on the evaluation of the common traits between these taxonomic groups studied. They concluded that there are morphological characteristics of plants that are always taken into account during plant identification by computer. Google search engine (https://lens.google.com): It requires two important things: First, it requires knowing the real scientific name of the target plant to enter its name in the search engine, and second, you must be lucky enough to know whether this or that plant is present in a reliable scientific encyclopedia, due to the large number of pages and sites where information is mixed and often contradictory, within websites. Image search engine (https://images.google.com): In fact, using it, we do not reach a result, unless there is a near-perfect match between the image of the plant taken by the camera, and another image of the same type that was previously archived on the Internet. This is difficult because the search engine gives you many possibilities, and you must search for the name of the target plant among many different images of plants. This is not a practical and tedious method and is not completely reliable. Artificial intelligence: Many universities and research centers in the world, such as America, Canada, Britain, Germany and other countries, are currently creating smart applications via mobile phones to achieve the best results in identifying plants, as indicated by [9], [10], and [11]. They have provided these applications with a huge number of digital images of plants, which have been captured and stored within this application. Collecting the stored data will help to automatically identify the target plant. These images may be of the entire plant, as indicated by [12], or of parts of it, such as flowers, [13] or together for flowers and leaves. Thus, to achieve the greatest possible accuracy in terms of plant recognition. There are currently more than 10 applications that adopt this method, such as: Flora Incognita - Pl@ntNet - PictureThis - Plant.id iNaturalist - Plantnet - Plant Spot - Planta - Plant Identifier - Plant Identification - Smart Identifier - PlantDetect Lite.... etc. In fact, most of these applications are still in the establishment phase, and the accuracy varies according to many conditions during the process of capturing the digital image. We can summarize that the process of identifying plants through applications that rely on artificial intelligence has become a focus of major global universities, institutes and research centers. We can also conclude that this is a great achievement in identifying the plant by simply capturing the image of this plant. However, it would be so if plant recognition in this way were 100% guaranteed. However, most authors of these applications point out that there is still a percentage of errors that are possible, according to Waldchen, director of research based on the Flora Incognita application at the Max Planck Institute for Biochemistry in Germany. In addition,[14] he pointed out the same criticisms about the Leafsnap application in the proceedings of the 12th Conference on Computer Vision (ECCV) held in Florence, Italy in 2012. If we go back a little to the scientific literature on how to distinguish between plant species, we find that there are certain parameters that can be relied upon to distinguish one plant from another or one plant group from another according to [7]. Any of these parameters is called a taxonomic characteristic, which means: any characteristic of an organism that can be measured, described or counted, whether visible or invisible, and is characterized by its presence in two distinct forms that can be distinguished from one another, and must be exclusively genetic. These visual characteristics will be the focus of our attention in this research for a simple

reason, which is that all scientific references have confirmed that all characteristics are worthy of study during the process of identifying or distinguishing between plants, whether they are visible or invisible, and there is no reason to point out the neglect of any characteristics. In this research, we are not in a classification process as much as we need to benefit from using the most important morphological characteristics approved by the approved international classification books. In addition to what we can observe from the external morphological characteristics during the different stages of plant growth and then automate them within this application in the form of keywords. In fact, we can say that if this application is relied upon, people who will use it will be able to identify the desired plant quickly, easily and in an enjoyable way.

3. Goal of research

The research aims to redirect the function of the ArcMap, which is a software, specialized in Geographic Information System (GIS), so that, anyone interested in medicinal and aromatic plants can learn about the name of the plant and its medicinal uses or other advantages, using this application, wherever he is. Through it, we can quickly identify this or that plant without resorting to paper references from various books and references, simply by placing the "keywords" about the visible morphological characteristics of the entire plant or one of visible organs as: stems, branches, leaves, flowers, fruits and seeds, etc., within the tables of ArcMap software.

4. Problematic of research

In fact, although rapid progress in modern technology uses to identify plants directly in the fields such as using smartphones to identify plants, these applications still have many criticisms such as:

- Lack of accuracy and many applications are still based on probability theory.
- Paying money because most of them are not free.
- Specialized in the countries where this technology is made despite the tremendous progress in modern technology.

We in this research are trying to provide a new application that differs from the mechanism of the work of smartphones related to manufacturing intelligence. The application that we accomplished depends on the researcher himself on the one hand, and the software used on the other hand.

5. Significance and justification the research

In fact, the process of identifying plant species and determining its therapeutic, nutritional and ecological properties is a prerequisite for many disciplines such as pharmacology, agriculture, science, wildlife etc.

In the field of pharmacology for example:

- If a pharmaceutical company indicated that, there is a beneficial, effective compound, and it would like to know what kinds of plants contains it. Through this application, we can find out all the plants that contains this compound very quickly.
- As, if the same company wanted to know where to find those plants, are found in nature, through this application, it is possible to access the locations of dispersed plant within the territory of country, and it can be generalized to include anther regions and countries wider.
- If someone wants to be acquainted with the largest possible numbers of medicinal and aromatic plants in his country, he must obtain this application after completing. We confirm again after completing this application.

6. Means of research

We used the following means:

- ArcMap is a software developed by Environmental Studies and Research (ESRI) at the National Aeronautics and Space Administration (NASA) in the United States of America. It is a

geographic information system (GIS), which deals with maps and satellite and aerial imagery. ArcMap is the former main component of the ArcGIS suite of geospatial data processing software from *Esri* (https://en.wikipedia.org/wiki/ArcMap). It is primarily used to view, edit, create, and analyze geospatial data. ArcMap allows the user to explore the data within a dataset, symbolize features accordingly, and create maps. This is done through two distinct sections of the program, the table of contents and the data frame. ArcMap users can create and manipulate datasets to include a variety of information. For example, maps produced in ArcMap generally include features such as north arrows, scale bars, titles, legends, stylized lines, and so on. The software package includes a set of styles for these features. In addition, there is the ability to load many other reference styles to apply to any mapping or function.

- A laptop equipped with an automatic charging battery for easy carrying while looking for identifying medicinal and aromatic plants.
- A metric ruler
- A mobile phone with a digital camera, preferably of high accuracy, loaded with the Global Positioning System.
- References about medicinal and aromatic plants.

7. Steps and method of research

Now, if we are faced with a plant located somewhere, in a garden, a field, a forest, a desert, the banks of a river or the sea, etc., we want to identify it. In this case, we will face two hypotheses:

7.1. *First, we have a preconceived knowledge about this plant*

Since we know the local and scientific name of the plant and its medicinal and therapeutic properties, and we have the desire to automate this plant within the relevant application, so that it is easy for anyone who comes after us to recognize it directly without any effort. In addition, we do not forget to photograph all the visible parts of this plant digitally as much as possible, such as stems, branches, leaves, flowers, fruits, seeds, etc. Then we enter these images into the application. However, the most important condition in this work is that we put "keywords" in simple and easy metaphorical terms for any part of the plant or even the general appearance of the plant, as we will explain later.

7.1. Second, we have no a preconceived knowledge about this plant

8. Results and discussion

We will discuss the results of the first hypothesis through the following application:

8.1. Practical example _1 (the first hypothesis)

We have a preconceived knowledge about the name of the plant and its medicinal and aromatic properties:

During our wandering on 7/4/2021 in the Ecological Garden at the Faculty of Science (Damascus University- Syria), we saw an herbaceous plant, in an advanced stage of growth, called *"Rosmarinus oficinales*". We stood a distance (about 2 meters) from this plant, and noticed the following features:

- **Leaves:** The plant appears to give the viewer more of the underside of the leaves than the upper side. The underside of the leaves also appeared paler than the upper side. The plant cover seemed so dense that we could not see the stems. When we touched the leaves with our fingers, we found that the pale white color of the underside of the leaves was due to the presence of very small white fluff, which gave them this pale color. We smelled our fingers after touching the leaves, and our attention was drawn to the presence of an aromatic smell similar to the smell of camphor

(note that previous smart applications that use smart cameras do not capture or smell the smell of plants, and this is the most important feature that distinguishes the application we are dealing with in this research from those smart cameras). The leaves also appear to be seated, opposite, thread-like, with a leathery texture, and downward-curving edges that are 2-3 cm long and 1-2 mm wide. In fact, these external characteristics are the same as those mentioned in the scientific reference [15]. However, it is possible to add an important remark that the sessile leaves always form a very acute angle with the stem to the point that the leaf partially accompanies it and then moves away as we approach the leaf apex, as in Figure 1. At least, we can see this morphological phenomenon before the flowers appear. At this stage of growth, we did not see the flowers because it seems that it was not time for them to appear. Finally, we recorded the most important keywords related to the leaves in the program table (Table 1) in addition to the medicinal and therapeutic properties of the leaves because we have prior knowledge about them.

Table 1- The most important of "key words", effective compounds, and other information about the leaves.

Branches

Branches	Key_words	Date(photos+Notes)
Rosmarinus oficinales	The branches holding the leav	7/4/2021

Leaves

Leaf	Key words	Effective Compounds	Preparation Method	Date(photos + notes)
Rosemary leaf	hite color of the underside of the heir is due to the presence of white micro-fluff The leaf has a sessile needle that n	Rosemary leaves contain vol	Rosemary leaves are used inte	14/4/2021

- **Branches:** holding the leaves were tender, and after we removed the leaves from them, they looked pale, tending to the same color of the underside of the leaves. After that, we noted the most important keywords related to the branches in the software table (table 2).

Table 2: Keywords, date of photos and notes about the branches.

- **Stalk:** we could not see it until after removing the upper parts manually due to its density. The stem appeared to be much branched and of varying and small diameters, its color tending to burnt gray covered with numerous peels that were easy to fall, and this is evidence of plant aging, because we do not see such scales in young plants. After that, we record the most important keywords related to the stem in the software table (table 3).

Stalk

Stalk	Key words	Date(Photos+Notes)
Rosmarinus oficinales	The stalk, we could not see it until after removing the upper shoots manua	7/4/2021

Table 3- Keywords, date of photos and notes about the stem.

Finally, we open the software and recorded the following apparent information that we saw about the plant in Table 4 within the software for the whole plant, in addition to the previous information related to the therapeutic, medicinal and aromatic properties that we know. Here, we also added additional information that is very important for those interested in collecting samples of medicinal and aromatic plants, which is the location and spread of this plant. This was on by determining the address of the location of this plant through satellite images, including the spatial coordinates, by means of a GPS device (table 5).

Location (Rosmarinus oficinales)

Location_1	GPS
Rosemary (Rosmarinus oficinales) - Location_1 - East of the canteen of the Faculty of Architecture - Da	【33】^0 【30】^' 【39.1】^" N, 【36】^0 【16】^' 【53.1】^" E

Table 4 - Information about the location and coordinates of plant.

We also adopted reliable scientific reference about this plant (Rosmarinus oficinales), whether university books or from research published in international refereed journals as [16], and other references within the software tables (table 5), to note general information as, taxonomic properties, effective compounds, medicals benefits, damages, preparation methods, location, scientific references, etc.

General Information

Local Name	Scientific Name	Family	Genus	Order	Class	Division	Kingdom	General Description	Effective Compound	Medicinal Benefits	Use Damages	Preparation Metho	Location	GPS	Date(Photos+N	Scientific Reference
Rosemary	Rosmarinus officin	Lamiace	Rosmari	Lamiales	Angiop	Mangolioph	Plant	A herbaceous plant of t	It contains a volatile oil,	It is used medicinally b	A small amount of it	*It can be used as a ri	Damascus -	[33]	14/4/2021	Calabrese, V., Scapag

Table 5 - Information about taxonomic, therapeutic properties, location, etc., for *"Rosmarinus oficinales"*.

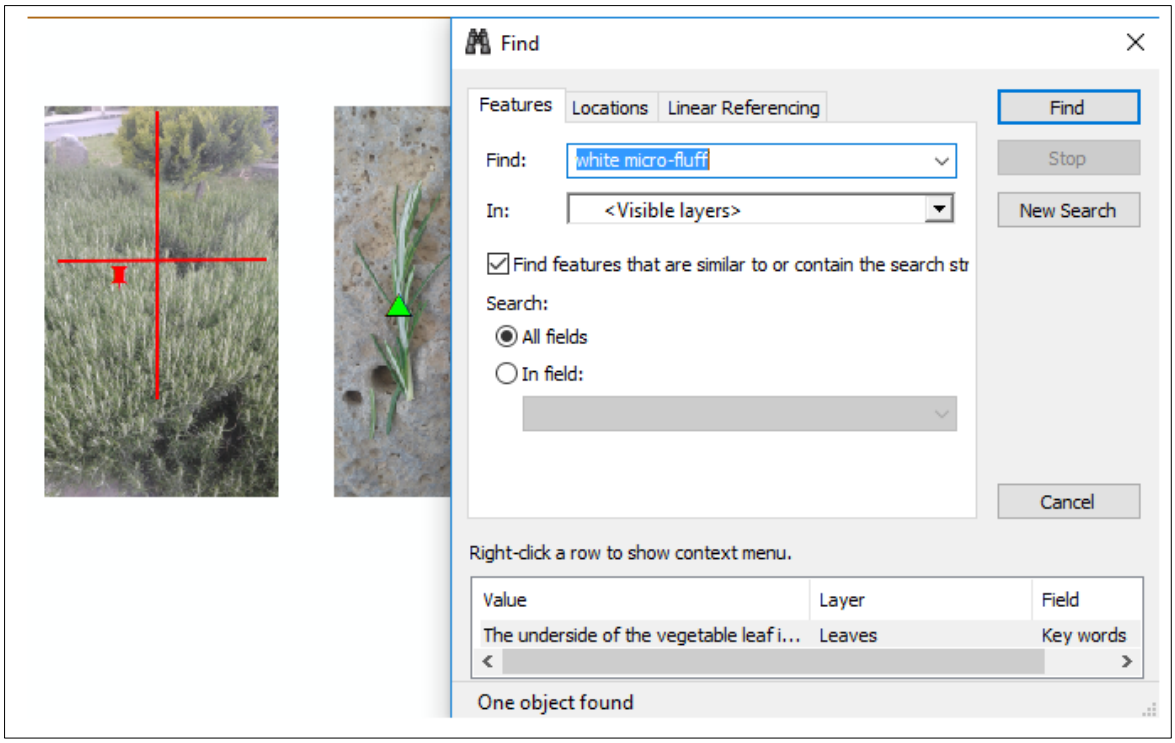


Fig. 1- Tool of ArcMap, for identifying the plant by using "keywords".

Now, someone somewhere, interested in medicinal and aromatic plants, saw this plant somewhere, and wants to know about this plant, what should he do? Firstly, he should have a laptop with this application installed, moreover, all the information, especially the "keywords" about this plant, should be archived in the application previously. The application opens to the main page of the Medicinal Plants Project. Inside the next search icon, as in Figure 1, he writes any noticeable note that caught his attention about any member of this plant, for example: he writes "white fluff" as "keyword". Immediately, two vertical and crossed arrows will appear above the plant with this property. By clicking on this intersection point, the name of the plant will appear with the scientific name, all its taxonomic characteristics, medicinal and aromatic properties, and even its location in nature with its spatial coordinates. If this person thinks that this plant is "rosemary" and wants to make sure of that without the need to put keywords, he can write the scientific name of this plant inside the previous search icon. The plant will appear directly to him as an image, and the intersecting arrows will point to it in the same way. Within electronic tables, the application will display all the images related to this plant in addition to tables of its various medicinal and aromatic properties.

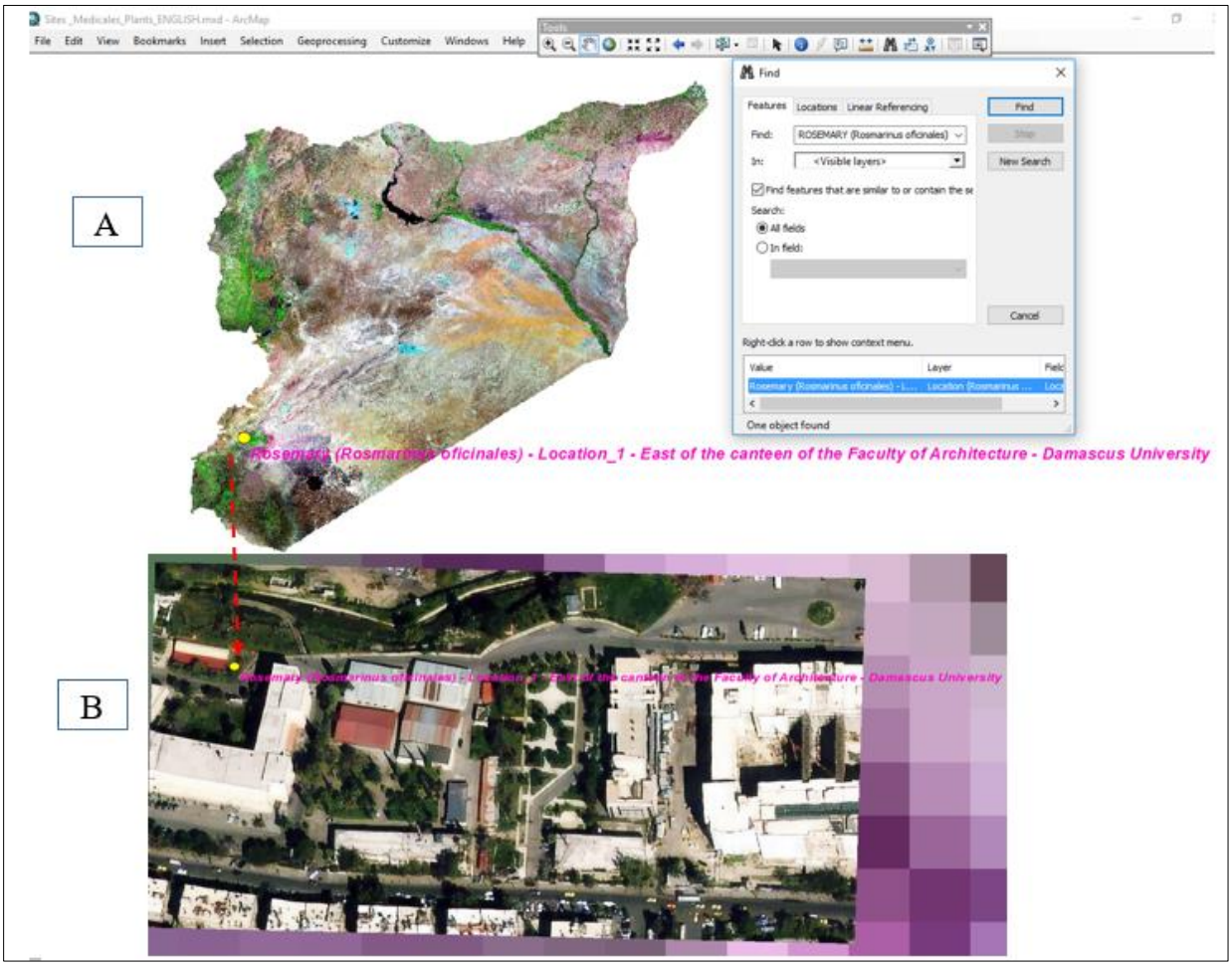


Fig. 1- Tool for identifying the location of Rosemary on a satellite image (Landsat, r: 30 m, 2021) (A), and an accurate image from Google Earth in high resolution (Bing, r: 0.5 m, 2021), (B).

The same person wanted to tell a friend about a place, looking for the location of this plant, he can send him the address without asking anyone else, he just has to go to the second part of this search and open the next page as in Figure 2 within the application and type the keyword "rosemary", (Figure: 2) two crossed arrows will appear indicating the geographical location of the plant, and he will get the following result with the most accurate details about the address of the plant's location with the help of satellite images (from Google Earth), which we have archived within the program. However, the questioner may ask us, maybe there is another plant other than “Rosemary”, or that many plants have "microscopic white fluff" on the underside of the leaf! The answer is yes, and this exists in nature, there are many plants that have this property, but we will not limit ourselves to this property only, but we will add the length and width of the leaf, for example. Do all plants within different species have the same length and width of leaves? In fact, after the application is completed and all the information is collected on as many plants as possible, of course, just typing “fine white fuzz” as a “keyword” will give us all the plants that have fine white fuzz on the underside of the leaf, and we can see it visually through the digital images archived within the program. However, we can reach the intended plant simply by adding another characteristic of the leaf within the same previous “keyword”, such as leaf length and width. Let us say there is another plant, or several other species that have the same leaf length and width, and then we move on to another keyword for another characteristic we recorded, such as “leaves have an aromatic smell”. If not, we move on to another organ such as the stem, flowers or fruits, so there must be a real difference because science says, especially genetics with regard to plants and any living organism,

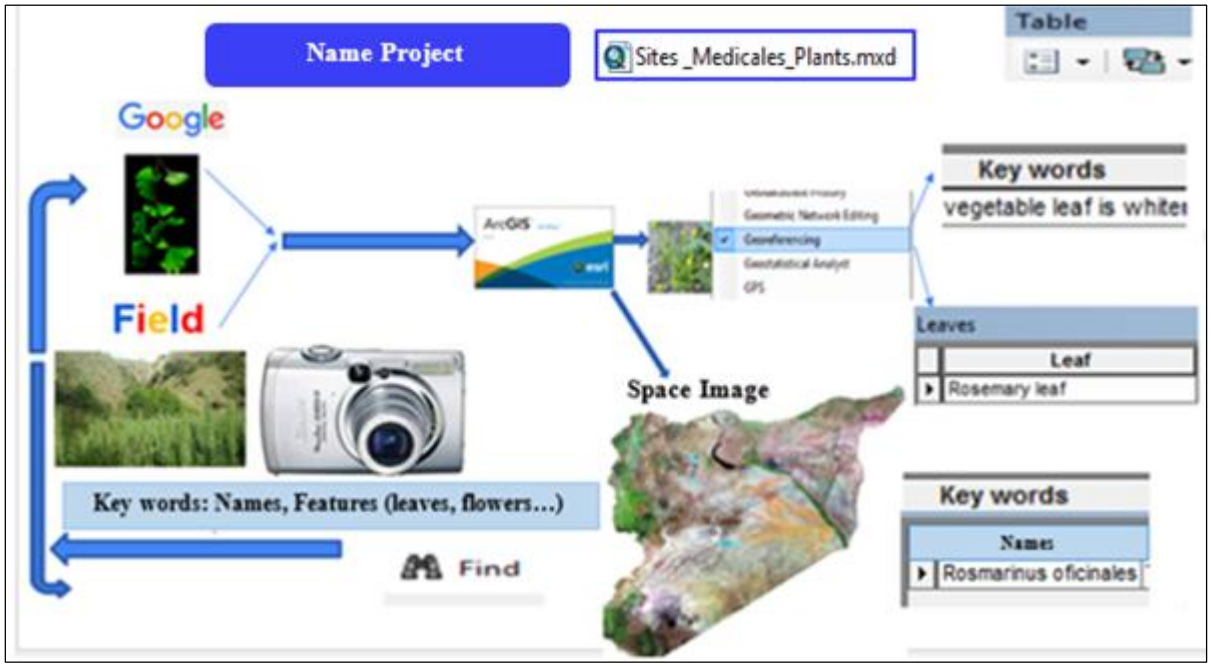
that no two plants are exactly alike, even if they are of the same species, genus, order, class and section [10]. On the contrary, we find that this application, once completed, will help researchers and those interested in knowing the extent of the relationship between plant species that share the same "keywords" and thus the same external and sensory characteristics. However, the questioner may ask us, using the search tool; we can search for any keyword within any other computer such as *Excel* and *Word* programs, and easily access the information looking for! To answer such a question: Yes, but the *Excel* and *Word* program interfaces are not sufficient to accommodate millions of digital images of plants, and do not contain pre-programmed digital tables to record the required information. In addition, their dynamism does not suit the input materials, i.e. images or satellite images, as they are office or statistical software. Moreover, we cannot link plants to their geographical locations spatially on maps or satellite images.

The benefits and advantages of this application

It does not need the Internet to work. The most important thing that distinguishes this application from the application of artificial intelligence is that we can reach to identify of the name of the plant by simply using "*keywords*" for apparent formal characteristics related to the appearance of the plant in general, or any organ. If, we are not successful to identify the plant from key words related to the flower, we may use another keyword for the leaf for example, and so in the end we will definitely come to know the name of the plant.

This is better than the imaging adopted in artificial intelligence applications because digital imaging requires many conditions. The process can succeed and may not succeed, and it can give several possibilities, i.e. several images of several different plants, and so on. Even if the plant name is given directly without any other possibilities, this needs to be checked and referred to the references to make sure of that as long as there is no application that gives a 100% match. In other words, doubt is always present and the possibility of error is possible and always present. We also emphasize that, the keywords will not be complicated, but rather they are expressed in common linguistic terms close to the mind. So that the cultural heritage in naming plants in many countries took its name from distinctive outward features, and the examples are many. There is also a very great possibility to unify these terms in order to be universal as long as they express the characteristics of a clear formal phenomenon related to plants to the eyes of any person present in any area and in any country of the world.

Notes: Of course, this application requires sufficient time due to the need for accuracy in obtaining information to reach the desired results. It is required for those who want to use this application to be familiar with some linguistic terms about the phenotype of the different organs of the plant when entering keywords to search for the name of the plant if they do not know it beforehand. Finally, through the following diagram (1), we can summarize the method of automating the previous medicinal plant or any medicinal or aromatic plant in general, whether we encounter it in nature (in agricultural fields or in forests) or even if we encounter a picture of it on different pages and sites on the Internet. To access the medicinal or aromatic properties, it is sufficient to put either the scientific name of the plant, if we have a preconceived knowledge of the name of this plant, and if we do not have prior knowledge, it is sufficient to enter any distinctive characteristic that distinguishes this plant, such as keywords, until we reach its scientific name and then know its various characteristics through the tables and views that make up the software in addition to the places where it is spread in nature after entering different satellite images into the program files. At the end of the automation process, we get an electronic extension (*.mxd*) with a name such as (*Sites_Medicales_Plants.mxd*) which is the name of the project through which we save all the automation steps and all the information entered into it. The fun thing about this program is that we can modify, add and delete information whenever we want.



Schema 1 - Steps of automated medical and aromatic plants using GIS (ArcMap) (with a preconceived knowledge).

9. Conclusion and recommendations

Based on the many benefits mentioned above, we can say that this application is an effective means that supports modern means that rely on artificial intelligence using photographs. This application is characterized by being free and does not require an internet connection. This application does not accept many possibilities to reach the target plant, as we have noticed in other artificial intelligence applications that rely on digital cameras. The interesting thing is that this application can be modified, added or deleted any information at any time we want, in addition to the spatial linking of plant locations in their natural distribution sites and locations. The use of keywords in this application increases our knowledge of the extent of kinship and similarity between plants in these characteristics, which will increase the knowledge stock to distinguish between the many and varied plants. Even the issue of repeating the same keywords for a member of the plant will certainly not be repeated for the rest of the members due to the innate and genetic nature of plants. In order for this application to be available and practically effective in our daily lives, it requires recording all medicinal and aromatic plants in a region or country, and this requires moving around and taking information about plants throughout the seasons because plants are in a state of gradual development, whether for annual or seasonal plants or even evergreens. We recommend through this research to continue recording any information about any plant that we may encounter in our daily lives or that we know in advance and know where it is spread because our ignorance and lack of knowledge of the benefits of many plants may eventually lead to their extinction, especially in sensitive areas that witness fires, uprooting and environmental degradation. Developing this application on a local or global level requires that this topic be adopted by one of the scientific institutions, similar to similar projects in other countries that seek to protect medicinal and aromatic plants in particular and biodiversity by identifying their medicinal and aromatic value in general and thus protecting them from deterioration and extinction.

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