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Review Article

Automatic Pill Identifier An Overview On Identifying, Retrieving And Authenticating Drug-Pill

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ABSTRACT

Around 6–8,000 individuals worldwide pass away every year as a result of taking pills erroneously. Patients may suffer injury from improper medicine usage, such as taking the incorrect drug or dose. In this overview a significant use of artificial intelligence (AI) for pill identification is discussed. Convolutional Neural Network (CNN)-based technique for automatically identifying a pill from a single picture OR Minimal Data (Color, Shape, Imprint). Using AI technology such as SIFT (Scale Invariant Feature Transform) and MLBP (Multi-scale Local Binary Pattern) descriptors, feature vectors that represent the imprint on the pill are created. Applications that facilitate medication reconciliation are increasingly essential than ever because of the substantial development in the prescribing and utilization of drugs. Pill identification demonstrate a deep-learning application that can assist in reducing errors that can be prevented and the danger they pose, such as accurately identifying prescription medications, a process that is currently time-consuming and prone to mistakes some of the examples are Pillbox, Drugs.com, Medscape, Help Me Pills, NIH(national institute of health), NLM(national library of medicine)Pill Image Recognition Challenge dataset to show how to identify prescription pills from smartphone photographs and the specification of the prototype, the computer vision algorithm used to extract pill features such form, size, and colors, as well as the decision tree that was employed to provide a rapid and accurate manner of pill identification.

INTRODUCTION

Oral pills like tablets and capsules are among the most widely used pharmacological dosage forms due to their greater stability and simplicity of administration. They frequently have different characteristics, such colors, forms, scorings, and imprints (letters, numbers, or symbols carved on the pills), which, to some extent, define their

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uniqueness. The packaging of the pills also contains information about them, which is important for pill identification and verification. Together, these two factors, together with the physical look of the pills themselves, are what make pills. Regardless of the various characteristics that a pill may have, as well as the self-explanatory information on the packaging, misidentification occurs on occasion, in which one tablet is mistaken for the other. Not only does pill misidentification result in fatal results for individuals but it also adds to medication error, which has a large financial impact on healthcare costs globally. According to, roughly 21% of patients do not adhere to their doctors' orders strictly, and just 6% are able to recognize common medications. In addition, between 12% and 20% of individuals use medication that was prescribed for another patient. An average patient considerably modifies the prescribed therapy in roughly 50% of cases, according to estimates. The primary causes of non-adherence to the advised pharmacological therapy include a lack of understanding about the medication administration process, the excessive number of various pills given in particular treatments, and simple errors or inadvertence. It goes without saying that the senior population is more likely to engage in such risky conduct.

It's crucial to completely adhere to the prescribed course of action while receiving therapies that call for daily medication consumption on a regular basis. The effectiveness of the recommended therapy may be reduced or rendered invalid if the dose and time are not followed, which might result in hazards to the patient's health and, in the worst situations, result in death.

INTRODUCTION TO AUTOMATED PILL IDENTIFIER:

In terms of patient safety and medicine identification, Automatic Pill Identifier is a game-changer for the healthcare sector. The danger of medication mistakes is significantly reduced for patients thanks to this technology, which gives them peace of mind knowing they are taking the proper prescription at the right time. Additionally, Automatic Pill Identifier gives medical practitioners the ability to swiftly and precisely identify unidentified tablets, ensuring that patients get the right therapy. By preventing the sale of fake medications, this technology also shields patients from potentially hazardous chemicals. Pill misidentification is predictable in a busy healthcare context, when healthcare practitioners are overburdened with a heavy workload interspersed with frequent interruptions and diversions. Pills with equivocal information on their labeling or packaging particularly lookalike sound-alike drugs are especially prone to misidentification. As a result, numerous solutions, such as medication naming systems and barcoding, have been advocated and implemented to limit the possibility of medication mistake.

Image retrieval systems have been the subject of several studies, and many of these studies are continuously working to enhance the models used to retrieve these pictures. One of the most common methods is to segment images using clustering algorithms. The non-linear k-means clustering approach is the most used clustering method, while there are many others available. Using a non-linear classifier and a convolutional neural network, a model for extracting pictures is suggested in the study that follows. In terms of feature extraction and classification, both techniques were used. A thorough analysis of a dataset with over 7,000 pill pictures representing 1,000 different types of pills gathered from the National Library of Medicine database shows that the suggested model performed far better than expected when it came to classifying the data. By utilizing Deep Learning, this study establishes the foundation for pill identification and verification. Through numerous layers of non-linear transformations, deep learning extracts abstract high-level representation from data. In speech recognition, natural language processing, and computer vision, the method has achieved outstanding results. It's noteworthy that representations learnt by Deep Convolutional Networks (DCN) have shown effective in capturing abstract notions that are independent of diverse visual phenomena. Face alignment, object identification picture restoration, image classification and face recognition are examples of DCN-based applications that have been successful. Here, we investigated and established essential work for fine-grained pill recognition utilizing DCN employing photos taken by commercially available portable devices like cellphones. The method will act as a crucial supporting technology for a practical, affordable solution that enables us to quickly detect and validate pills. The many stakeholders in the healthcare system are expected to find this technology to be a priceless instrument.

The mobile system operates in two modes:

a. Learning
b. recognition

The first mode manages the storing and profile of targeting pills. This method begins by obtaining the picture of the pill and marker. The next step is to normalize the image size (1024x768). Following the discovery of the markers, the referred profiling is carried out based on the identification of pill color, size, and shape. Finally, all of this information is correctly placed in the system's database for future reference. The recognition mode, on the other hand, focuses on pill detection based on pill profile and feature filtering. The capture and resizing of images is the first step in recognition, much like in learning mode. Next, the pill is subdivided, the marker is found, and the filtering process is performed. During feature identification, the major goal of this filtering is to systematically reject groups of tablets. The first distinguishing characteristic is shape. After estimating the shape, the system does a database query to get the shapes that correspond to the estimated one. Then, using an approximation of width and height, size is determined in order to select pills from the current pill subset. In order to apply a color filter on the remaining subset, colors are lastly chosen.

One of three outcomes are possible at the end of the process:

Either no pill was discovered, a pill was found, or more than one pill was found. Also indirectly linked to user roles are the learning and recognition modes. Adding the medications to the database of the system is the caregiver's responsibility. The learning mode on the system's management module is thus used by the caregiver to accomplish this goal. However, it is important to provide older people information about medications. This user automatically makes advantage of the recognition mode accessible on the application frontend when he or she wants to learn more about a certain medication. The specification of the prototype, the computer vision approach used to extract pill attributes including form, dimension, and colors, as well as the decision tree that was used to give a quick and reliable method of pill identification, will all be exposed in the following parts. Additionally, the intended usage scenario will be displayed in order to clearly define the order of actions that the elderly should take while accounting for any loss of abilities, such as the ability to point precisely.

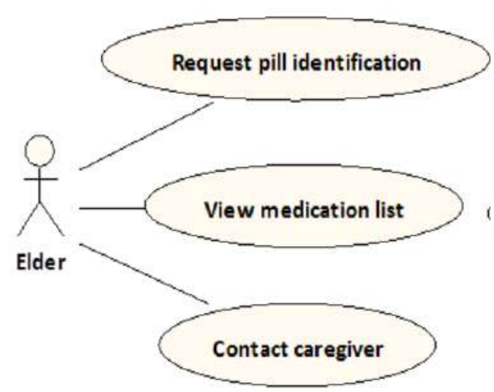


Fig. 2.1: Functions available for elders

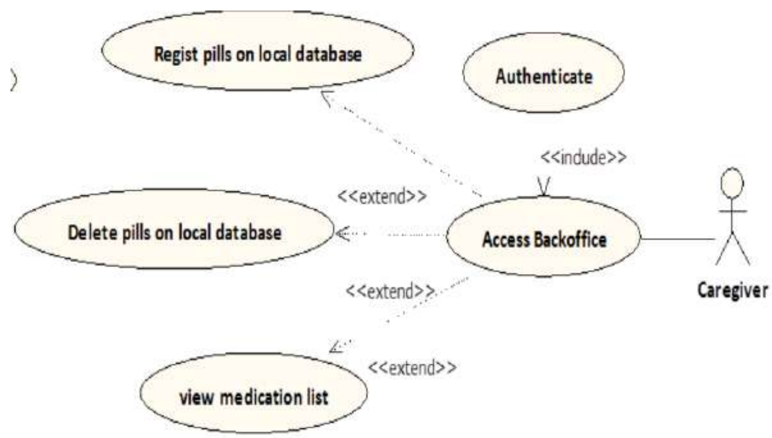


Fig. 2.2: Functions available for caregivers

THE SYSTEM OVERVIEW:

Identifying:

It is the technique of identifying a medication's name, strength, and other pertinent details simply from its visual characteristics, such as its size, shape, colour, imprinting, and packaging.

Retrieving:

Once a pill has been detected, automatic pill identifiers frequently extract detailed information on the drug. Name of the medicine, manufacturer, components, dosage, indications, warnings, adverse effects, and directions for use are a few examples of the data that may be included.

Authentication:

It entails confirming that the specified drug is authentic and not a fake. To assist users in determining the legitimacy of a drug, certain systems may include features or tools, such as the ability to look for distinctive package identifiers.

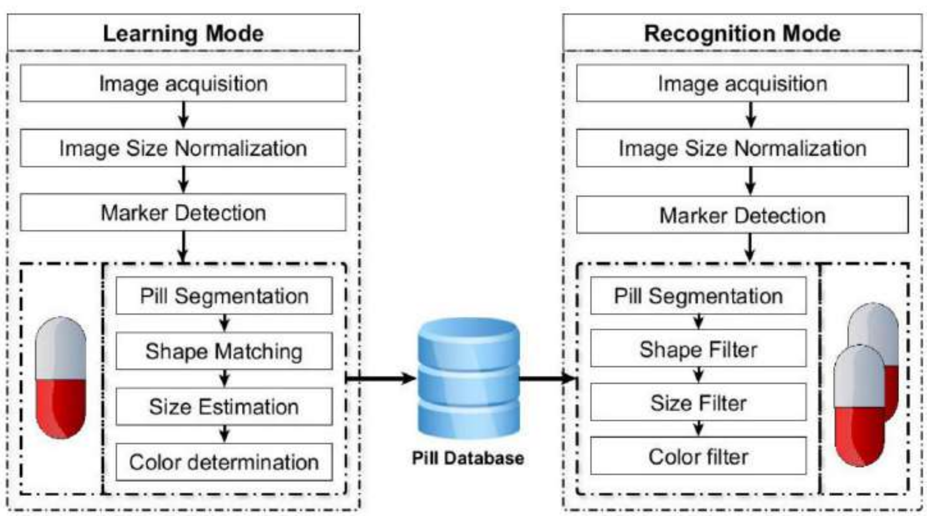


Fig 3.1: System working module

APPROACHES:

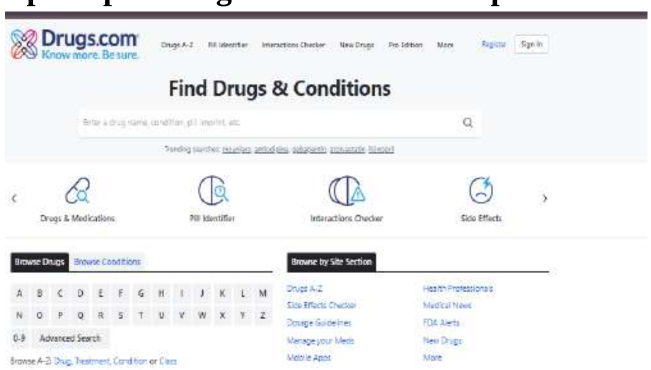
A device known as an automatic pill identifier uses computer vision or software not based on computer vision to recognize and confirm the legitimacy of pills.

Non-computer vision-based approach

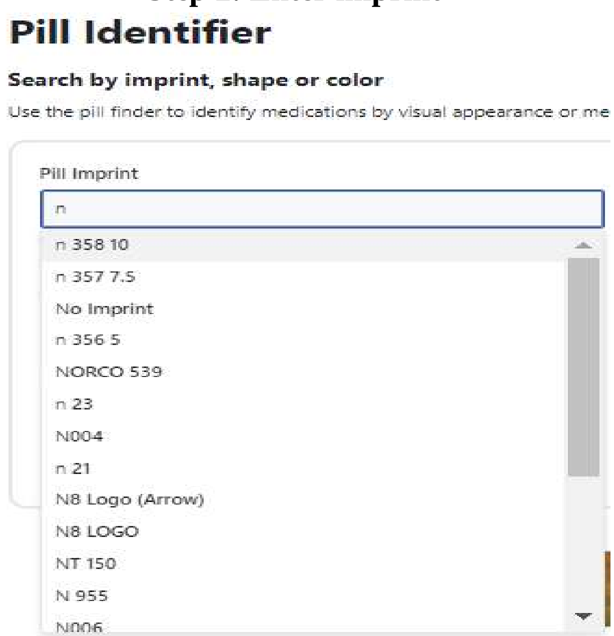
A number of online tools are now accessible to assist with pill identification, such as the "Pillbox" by the US National Library of Medicine the (NLM) and national institute of health (NIH) "Pill Identifier" by Medscape, and the "Pill Identification Tool" by WebMD. The user interfaces of these online platforms are similar, and users are needed to manually enter or pick from drop-down menus a variety of characteristics relating to the pill in a query, such as its shape, color, and the presence or absence of imprints and scorings. These portals offer a useful database for pill searches, but they are not without their share of difficulties. First, the dropdown menu options could not fully encompass the features sought. This is especially apparent when it comes to color selections because since color is a continuous property, it is hard to literally define each hue and its tones. Second, human entry of the data is vulnerable to user subjectivity, for instance in how people interpret colors. Third, if there are several tablets that need to be recognized, the manual entry requirement might take a long time.

Taking an example Drugs.com How it works?

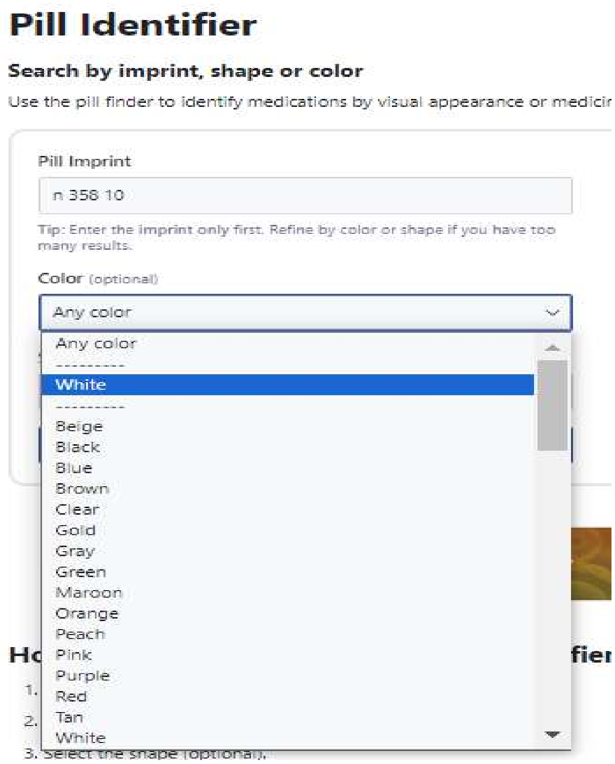
Step 1: open Drugs.com and click on pill identifier



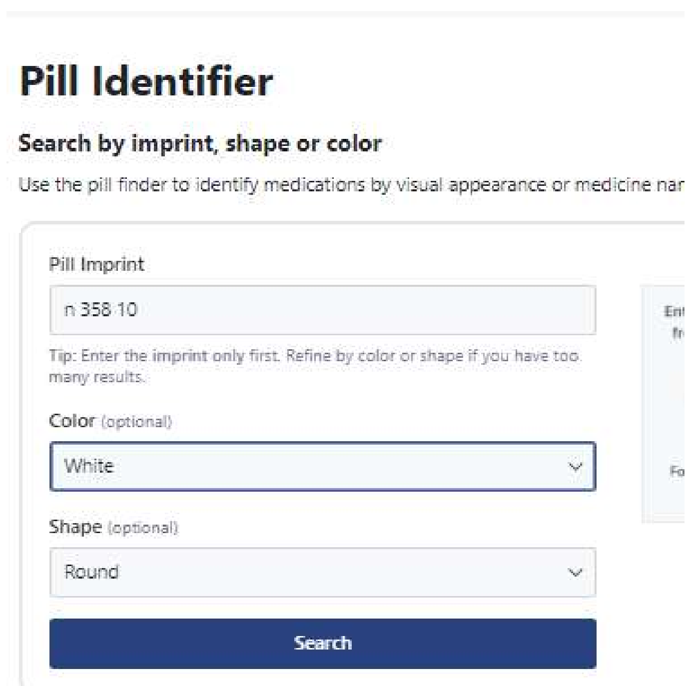
Step 2: Enter imprint



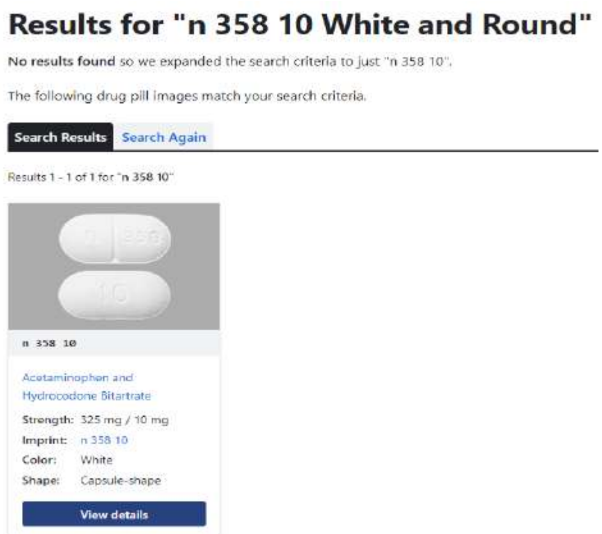
Step 3: Enter colour



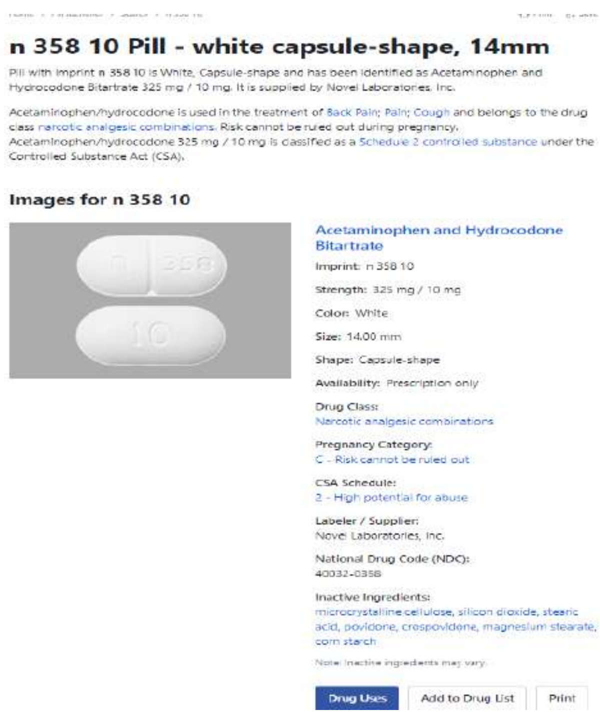
Step 4: Enter shape



Step 5: Click on search and find results



Step 6: click on details for more information



Computer vision-based approach

Numerous strategies have been put forth to identify tablets automatically by computer vision in response to the requirement for precise pill recognition .Every study that has been done so far has created some visual cues for identifying pills. Due to its resilience to changes in lighting, hue, saturation, and value (HSV) color profiles are typically the basis for color features. Shape is among the most common handcrafted visual elements, next to color. The first phase of the procedure is to identify the shape of the pill. In order to create a distance vector that accurately depicts the shape of the pill, points are equally sampled along the contour and their distances from the mass center are calculated. Then, statistical data may be retrieved as features, including maximum, minimum, and standard deviation. As an alternative, the form similarity of any two pills may be measured by computing the cross-correlation of their respective distance vectors. This will produce a score. It has also been implemented to use hu moments of form contour.

On imprint extraction and representation for pill recognition, several experiments have been conducted. Examples are Chen and Kamata and Yu et al. who primarily use the imprint characteristic of tablets based on modified stroke width transform for recognition. In different research, the imprint pattern is described using the Scale Invariant Feature Transform (SIFT) and the Multi-scale Local Binary Pattern (MLBP). In the event that the improper design is adopted, the design is not data driven and may not generalize well. If useful traits can be automatically picked up using a general-purpose learning technique, this issue can be overcome. The deep convolutional network is the one used in this research since it has demonstrated excellent performance in a variety of real-world computer vision applications, including picture classification

a. Data collection

At the Department of Health Sciences at the Caritas Bianchi College of Career, 400 widely used pills and capsules were gathered from the dispensing laboratory. Pills for the cardiovascular system (28.5%), nervous system (18.8%), gastrointestinal system (9.2%), endocrine system (8.8%), infection (7.7%), blood and nutrition (6.9%), musculoskeletal system (6.7%), respiratory system (6.3%), genitourinary (3.5%), immune system and malignant disease (0.6%), dermatology (0.2%), and others (2.9%) are included in this category. The dose forms, presence or lack of imprints, shapes, and colors of the tablets were used to classify them. All of the pills were arranged on a reference sheet, and photographs were shot using two mobile devices, each running a different operating system, at a resolution of 72 pixels per inch. As long as they stayed inside the reference board's perimeter, pills were being put in random locations. In order to more accurately depict the usage situation in the actual world, several perspectives, distances, and lighting setups were purposefully used to obtain pill photographs. Fig. 2 displays a sample of the photos that were captured. Each pill was photographed between ten and twenty-five times, encompassing the front and back, for a total of 5284 photographs. Random partitions of 4884 were created for the training-test portion of the pill dataset.

b. Process

OpenCV, an established image processing library, is used in the computer vision process. With regard to the pill learning and pill recognition modes, the mentioned procedure functions as intended. To get a normalized size for each frame that is captured, a frame is first taken and scaled to 1024x768. The marker is then discovered in order to limit the processing region. In order to achieve learning and recognition, form, size, and color are finally processed. The next items will go through these four phases in more detail.

c. Detection

In this approach, a very specific identifier is utilized, and it has certain properties. It is made up of a large white square with four perfectly aligned black circles that are positioned such that their centers distinctly create a rectangle shape. There is a dark square that is known to be 5x7cm in size inside the rectangle that these circles make. In order to ensure a successful processing, the pills must be positioned inside this last square. In order to recognize a marker with such qualities, various requirements must be checked counting with the aid of the selected library OpenCV. Beginning with a search of the squares contained in the picture, the method uses Canny to detect edges and a mixture of contour discovery and polygon approximation to find contours. Afterward, the program looks for four circles making a rectangle for every square. In order to locate the black square inside the rectangle produced by the four previously discovered circles, Canny is then used once more. In the event that the process successfully completes this stage, the technique then tries to find and categorize tablets inside the final black square discovered.

d. Shape Processing

Inside the resulting black square, the algorithm looks for markers before looking for tablets. Pre-processing is carried out at this stage. Along with Canny for edge detection, contour discovery, and polygon approximation, this also provides Gaussian Blur, Otsu threshold, and Gaussian Blur. As a result of pre-processing, a collection of points that describe a pill's form and are segmented for its bounding box are produced. Then, using a shape matching function based on Hu-Moments , the contour of the form is compared with template shapes in the database to decide which one is the most similar, out of the following list of options, chosen from the websites previously mentioned: Any triangle, square, rectangle, diamond, hexagon, octagon, circle, ellipse, or oblong can be used. Hu-Moments are preferred in this situation since comparison happens regardless of size, rotation, or pill location. The best match is shown by the comparison's lower value.

e. Dimension

Processing The size of the pill is determined by measuring the smallest side of the black square housing the tablets, which is known to be 50mm in length, and using the minimal rectangle that encloses the pill as a starting point . Calculating the actual dimensions is very easy when using the provided millimetre value and the relationship in pixels between the marker side and each pill's smallest rectangle. This assessment seeks to establish the precise height and breadth of each pill, which will then be stored.

f. Color

Processing To reduce computing load, the classification of color begins with an image sample. Following that, a discrete LUT is built using database HSV color values. In order to homogenize the picture in accordance with the LUT, the color space of the image is also changed from RGB to HSV. Only the pixels inside the pill's shape are taken into account in the pixel-by-pixel comparison method to determine color. Each of these pixels is categorised by comparison with the LUT table. The last step is to count each color's pixels and eliminate any that have a low pixel count. Shape, dimension, and color processing are the phases that the learning process follows in order to acquire all the data related to these three aspects. In contrast, the recognition procedure filters pills using a decision tree. The acquisition of the picture including the target and pill initiates the recognition process. The recognition algorithm looks for a match in the database after determining the shape of the unidentified pill on the marker. The decision tree's initial node selects pills according to form. In this way, a database query is done to find pills with the same shape description. If more filtering is necessary based on the results, the procedure moves on to the next decision node. The procedure moves on to the second node of decision-making if the outcomes need further filtering. Using dimension as a filter, this node eliminates the remaining pills. In terms of height and width, the margin value is 1mm. The third node is employed if more filtering is required. The most complex decision-making node is the third one. The results of the color matching test on the remaining tablets at this stage can be one of three things: Success: the pill was located; Indecision: a number of pills were located; Failure: no pills were located. At this level of development, the system notifies the user of the outcome of the recognition process, allowing him or her to get in touch with the caregiver through a rapid dial button in the event of uncertainty or misidentification.

CURRENT USAGE SCENARIO:

A few presumptions were considered when Help Me Pills was created. The mechanism presently functions for solid tablets in the first case, which is for medications. User characterization is another set of presumptions. The system ought to provide seniors over 50 with a high level of autonomy and independence. Additionally, they depend on medicine to maintain normal health. User expectations and attitudes are a last crucial factor. The user in this instance seeks assistance from the software. He believes that in exchange, the system will be more dependable and self-sufficient, which will make up for the performance lost. In light of the assumptions made by António Cunha et al., we now outline a use scenario in which the system aids the user in performing medication-taking tasks. A mobile device with a pill recognition program loaded is carried by the user. Reach at waist level on a table or other flat surface when consuming. He starts preparing the conditions for the pill recognizer's efficient operation here. Place a foundation, such as a stack of books or another commonplace item, on top of it. The height of the mount should not exceed a maximum of 34 cm, and a maximum of 10 should not be less than cm, according to earlier testing using a Samsung Galaxy Note II smartphone with an 8-megapixel back camera and a 5.5-inch display. Place the pill on the marker's black area after that. The user's mobile device then starts up a tablet recognition program. When the gadget is set up on the designated support, around two-thirds of its surface should be steady, and the camera should be pointing squarely at the mark. After going through these stages, the user collects all of the requirements needed to take pictures of the medication and marker. Instead, after completing an imaging job, the user is given pertinent information about the medication, such as its name, recommended intake times, and dosages, as well as a list of the targeted symptoms and illnesses, while also taking into account the tablet's size, color, and writing. The objects needed to complete the scenario are shown in Figure 4 along with the order in which they are utilized. The viability of the process is the focus of the scenario's decisions. No specialized equipment is needed. The environment may be swiftly prepared for pill detection by the user and things around are conveniently within reach. However, the recommendation to set the mobile device down on a level, solid surface accounts for the possibility of impairment and the signs and symptoms of certain illnesses, such as tremors, which can make it more difficult to capture an image of the pill.

Some free to use software:

1. **Pillbox (by the National Library of Medicine):**

This is an online identification tool that allows users to enter the physical characteristics of a pill, such as shape, color, and imprint, to identify the medication.

2. **Drugs.com Pill Identifier:**

A mobile app that helps users identify pills based on their physical appearance.

3. **GoodRx:**

While primarily known for its price comparison service, the GoodRx app also features a pill identification tool.

4. **Epocrates:**

This widely-used medical app includes a pill identification feature in its free version.

5. **RxList Pill Identifier:**

A web-based pill identification tool offered by RxList, which allows users to search for pills using various characteristics.

6. **Medscape:**

Besides providing medical information, the Medscape app also includes a pill identification tool.

7. **ID My Pill:**

A mobile app available on both iOS and Android platforms, allowing users to identify pills based on their appearance.

8. **My Therapy:**

An app designed to help users manage their medication schedules also includes a pill identification feature.

First Databank's Pillbox/Unbound Medicine Pill Identifier:

A pill identification tool available through various healthcare websites and apps.

9. **Health line Pill Identifier:**

A web-based pill identification service provided by Health line.

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