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A Survey on Hyperspectral Sensing Techniques for Identification of Fake Pharmaceuticals Medicines

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***Abstract*— Risky or subpar medications are indeed an issue for healthcare organizations, especially in middle-income countries with inadequate pharmaceutical care and pharmaceutical legal frameworks. Impoverished pharmaceuticals can lead to major adverse drug reactions, the emergence of bacterial resistance, as well as the possibility of therapeutic failure. They can also raise medical costs and erode the trust of the people in medical institutions. In the rapidly growing world, the study of fake pharmaceutical medicines is crucial. Hyperspectral imaging (HSI) is a developing imaging technique for use in medicine. The dataset, which has three dimensions, two spatial and one spectral is acquired via HSI. A summary of the research on hyperspectral sensing techniques for the identification of fake pharmaceutical medicines is provided in this research article. This study aims to evaluate the available various technology for identifying fake medicines.**

***Index Terms*— Hyperspectral imaging (HIS), Raman hyperspectral imaging, spectroscopy, fake pharmaceuticals medicines, spectral signature, Visible to near-infrared region, Spectral data analysis.**

I. INTRODUCTION

The impact of fake medicines on society has a global reach. Due to massive distribution paths, unauthorized online pharmacies, and reused materials and packaging, they are difficult to identify. It is necessary to develop detection techniques for identifying fake medicines as well as various techniques for confirming counterfeiting to solve this problem. For the identification of fake medicines tablets, various challenges are rising day by day. Developing a new technique to identify fake pharmaceutical products with appearance inspection. Now the rapid development of identification techniques in that analytical, chromatography, and spectroscopy are available but these techniques are taking more time, more data, or maybe impacting the environment. So, to reduce this problem need the development of new techniques or methods. Selling in fake medicine (FM) the prevalence of fake or poor medications is increasing. Quite striking, particularly as the leading medical products or medications there is no need for a permit. A primary goal in rich nations, exercise is a costly medication of living (hormones, steroids, appetite suppressants, medications for premature ejaculation, Psychotropic drugs) whereas, in underdeveloped regions, daily existence pharmaceuticals (Tablets of antibiotics, antimalarial, antituberculosis, antiretroviral medicine) are the objective [1]. **Error! Reference source not found.** shows the categories of fake medicines with its definition. Substandard medicines are approved medical item that does not meet benchmarks,

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regulations, or sometimes both, and is often referred to as hazardous and pharmaceutical ingredients which purposefully or falsely conceal their origin, name, or even content. Those standards were completely contradictory; therefore, a sampling may only be categorized as being either sub-standard or falsified by the world health organization (WHO) [5]. Medicines that lack active pharmaceutical ingredients (APIs), in addition to those that include incorrect substances that could or could not be dangerous, are counterfeit.

TABLE 1:FAKE MEDICINE CATEGORIES

Categories	Definitions
Substandard	Medications that fall short of quality standards and criteria are known as poor or substandard medications [2].
Falsified	Falsified medications seem to be imitations of legitimate medications made from bogus components [3].
Counterfeit	Medications that can violate copyrights or trademark infringement are considered counterfeit [3].
Diverted	The unauthorized transfer of authorized medications from credible sources to the black market is known as prescription medication diverting [4]

The world health organization (WHO) has noted that counterfeit medications have identification the illegally source information purposefully and misnamed. Several nations definitions of the word counterfeit medication have made it difficult to share information among them or truly comprehend the scope of the issue on a worldwide scale [6]. Various categories of counterfeit medications are distinguished, and that can be found using a variety of analytical techniques. Some of the most typical products include those having an inadequate amount of the active ingredient or products with no active ingredient at all. 15.6 % of items are packed wrongly, and 21.4 % of products are constructed using inappropriate material. 8.5 % of the precise product's genuine copies have significant contamination [7]. Fake medications with a wrong dosage of an active component. It can cause a variety of medical conditions. Minimal antibiotic treatment may not eradicate the germs but it could cause the growth of bacterial resistance. In Cambodia, fake malaria medicines killed 30 people in 2000 [8]. In 1993, more than 100 kids in Nigeria were killed as a result of a toxic chemical found in fake cough syrup. Due to the presence of ethylene glycol in cough syrup in place of glycerol, comparable cases occurred both China and India during the time period 1990 and 2007 as well as in Panama. Around 190,000 people died in 2002 as a result of polyethylene glycol poisoning in paracetamol syrup [9].

Fake medications with an undeclared active component. Recreation medications with potential botanical constituents are a typical target for this kind of fraud. Despite being healthy, cannabinoids could nonetheless have certain pharmaceutical consequences for the body. Therefore, it needs to be considered, and using such medications must be used with a prescriber. Four children cough syrups Promethazine oral solution, Kofexmalin baby cough syrup, Makeoff baby cough syrup, and Magrip N cold syrup have recently been labeled as substandard by the WHO after causing kidney problems and the deaths of about 66 kids in the Gambia [10]. According to the literature, fake medicines cover practically all pharmaceutical medicines types such as antimicrobials, antimalarials [11,12]. erectile dysfunctions, herbal, diabetes, and weight control [13].

A. Hyperspectral Remote Sensing

HRS (Hyperspectral Remote Sensing), also known as imaging spectroscopy, can give good image spectral information. Researchers and scientists have investigated and applied imaging spectroscopy techniques for the detection, identification, and mapping of minerals on land, in waters, and the atmosphere, based on the characteristics of HRS, which combine imaging with spectroscopy and possess individual absorption features of materials due to specific chemical bonds in a solid, liquid, or gas. As a result, HRS technology, as an enhanced remote sensing instrument, has been explored for a variety of applications, including geology, geomorphology, and environmental monitoring, etc. [65]. Hyperspectral Imaging (HSI) is a technique that examines the entire wavelengths of colors instead of identifying primary colors RGB (red, green, and blue) with each pixel. So, the light reaching every pixel is divided into numerous separate wavelength channels and provides additional details about what has been viewed. The unique color signature of an individual object may be recognized using HSI. Unlike other optical technologies that can only detect a single color but hyperspectral imaging can detect the whole color spectrum in each pixel [66].

Standard RGB photographs display a basic contour and color they can always distinguish between connected component sampling that shares the same contours and color that varied in their materials responses. Obtain the same, particularly when it comes to pharmaceutical prejudice. A primary between hyperspectral images and standard RGB data is the higher Spectrum Resolution and larger Spectrum Range of hyperspectral data. Figures 1 and 2 demonstrate that the hyperspectral signal contains additional data than the standard RGB data. An earlier technique for image processing is much less suited for hyperspectral data since data is considered hyperspectral it has more than a hundred plus bands [67].

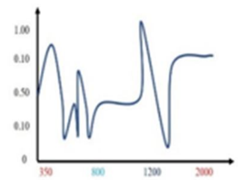

Figure 1: Hyperspectral data

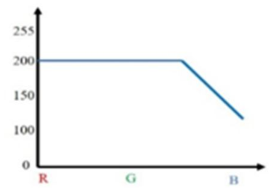

Figure 2: Standard RGB data

For the identification of active pharmaceuticals ingredients in medicines use the hyperspectral data. In hyperspectral data, a target at a high number of distinct wavelengths is described as hyperspectral imaging. In its most basic form, hyperspectral data is a data cube in which the first two dimensions indicate spatial distances and the third represents the spectral wavelength or wavenumber. Hyperspectral imaging is used in various applications like remote sensing, agriculture, and food, also be used in pharmaceutical studies [68]. The advantage of the technique is it required little sample and do not make use of any chemical or solvent, which is increased safety, reduced negative environmental impacts, and save chemical laboratory analysis cost. When the data is captured by hyperspectral image sensors all the chemical information is in a given spectral range. Thus, with appropriate data analysis, it is simultaneously determining several quantitative properties with a single scan image.

II. RELATED WORK

To start, we looked through the existing literature for academic journals, original research, conference papers, and case studies that are available on different platforms like Google Scholar, IEEE Xplore, and PubMed (Medline) repositories. The multidisciplinary character of the research objective, which required a review of the science/health research, has been the justification for selecting those resources. Hyperspectral imaging (HSI) is a developing imaging technique used in medicine, particularly in the identification of fake pharmaceuticals. A literature review has focused on the study of the identification of fake medicines using hyperspectral imaging, multispectral imaging, Raman hyperspectral imagining. *TABLE II* shows hyperspectral imaging's various applications in the medical field.

An infrared absorption band-based multimodal PLS-based quantitative study of produced tablet content was built. The study's aggregate result with 7 suspect paracetamol tablet tests, or 12%, is roughly in line with WHO assessments for such amount of inferior or counterfeit pharmaceuticals marketed internationally. The numerical study for this wavelength range (1524-1493 cm-1) revealed no errors [33]. Near-infrared spectroscopy (NIR) is being to quantify the active components in semi-solid pharmaceutical preparations. This study assessed how well six distinct dermatological semi- solid pharmaceutical formulations could be quantitatively inspected using a NIR spectrometer with a restricted wavelength range (1000–1900 nm). The accuracy and variance are highly dependent on the active component and the range of its concentrations [34]. ASD FieldSpec4 Spectrometer was used in a study for the spectral database of pharmaceutical common excipients and active pharmaceutical ingredients. It has a broad spectral range (350-2500 nm) and its supporting software were need derivatives along with a derivative gap of 7 are employed as pre-processing approaches. ViewSpecPro software is used to display the output of the spectrum database as figures for each sample [31]. The strategy was applied to real or fake Viagra and Plavix materials. A margin of error of 15 to 24% was used to determine the amount of active medicinal component. The methodology may now be used to provide a first estimate before the application of further quantitative approaches [35]. Phosphodiesterase type 5 inhibitors have a murky online market that is booming. Because fake medical products could make the user feel sick, medical practitioners may get sceptical of them. The authentic drug and Cialis pills from dubious internet pharmacies were also examined in this investigation. Using infrared and Raman spectroscopy, it was possible to detect the bogus pills and establish

TABLE II: APPLICATIONS OF HYPERSPECTRAL IMAGING SYSTEMS IN MEDICAL

Spectral range (nm)	Methods	Application	Method of measuring
440 -640	Hyperspectral imaging	Skin cancer [14]	Fluorescence and Reflectance
500- 600	Medical hyperspectral imaging (MHS	Diabetic foot [15]	Reflectance
450- 650	Hyperspectral imaging	Endoscope [16]	Reflectance
365- 800	Hyperspectral imaging microscopy	Melanoma [17]	Transmission
400 -720	Hyperspectral imaging	Tumor hypoxia Microvasculat-ue [18]	Fluorescence
450 - 700	Medical Hyperspectral Imaging	Breast cancer [19]	Reflectance
400 -1000; 900 - 1700	Hyperspectral imaging	Intestinal ischemia [20]	Reflectance
450 to 950	Hyperspectral imaging	Prostate cancer detection [21]	Reflectance
2500 - 11,111	Fourier transform infrared spectroscopy	Breast cancer [22]	-
500-3500	Raman hyperspectral imaging	Substandard Antimalarial Tablet [23]	-
1000-2500	Hyperspectral imaging	Classification of drug tablets [24]	Wavelength
1000-2500	Short wave infrared hyperspectral imaging	Detecting counterfeit drugs with identical API composition [25]	Wavelength
350 -1050	Hyperspectral imaging	Detection of Counterfeit Medicines [26]	Reflectance
1000 -2500	Near Infrared spectroscopy	counterfeit detection a large database of pharmaceutical tablets [27]	Reflection
4000–12,000 cm	Near infrared spectroscopy	Illegal synthetic adulterants in herbal anti-diabetic medicines [28]	Reflection
1730–174 cm−1	Raman spectroscopy	Identification of counterfeit drug [29]	Wavelength
4000–400cm−1, 1000–4000cm−1	Fourier transform infrared spectroscopy, Near-infrared spectroscopy and Raman spectroscopy	Detection of counterfeit medicines [30] Detection of falsified antimalarial drug [31]	Reflectance
1001-2500	Hyperspectral non-imaging	Pharmaceutical Common Excipients [32]	-

their API and excipients [36]. Aripiprazole in pharmaceutical formulation and bulk is detected quantitatively using high-performance liquid chromatography (RP-HPLC). According to the study, recovery experiments and the computation of the percent return were both used to assess the method's reliability [37]. Fake medications were examined using portable Raman spectroscopy with tailored localized plain views. Local Straight-Line Screening (LSLS) as well as fundamental problems severely (PCA). An algorithm was used to identify the fake drug mixed with herbal medications. To detect suspicious fake medicines, the LSLS technique was extended to Raman Spectroscopy by weighting developed false positive false negative ratios adjustments [38]. A total of 26 anabolic androgenic substances (ASA) tablets are founds. Outraged, the developed technology has been applied to products intended to promote stronger and larger muscles. UHPLC-MS (ultra-high-performance liquid-tandem mass chromatography spectrometry) technology has been developed and approved for screening and quantifying AAS found in counterfeit medications and supplements [39]. Hyperspectral detection is a method are used have to detect fake medicines tablets. By adding different amounts of calcium carbonate, these medication powders have been modified to mimic fake medications. For this study, a hyperspectral sensor that operates in the visual range and near-infrared (350–1050 nm) range was utilized. The findings suggest that we would achieve a classification accuracy of greater than 90% [40]. To study to identify fake drugs, counterfeit drugs were detected using image analysis and processing, within range of visible near-infrared (400-1000 nm) and short-wave infrared (1000-2500 nm) hyperspectral imaging. Pfizer Viagra original product and imitation pills were compared. The Gray-Level Co-Occurrence Matrix (GLCM) analysis allows for the assessment of the homogeneity of pill component distribution [41].

53 formulations from 29 distinct medicinal product families have been measured, producing a massive library of spectra. The principal component analysis (PCA), the K-Nearest Neighbors (KNN), the support vector machine

(SVM) and the discriminant analysis (DA) were among the chemometric methods used to analyze the data. Near-infrared spectroscopy is used for the identification of pharmaceutical tablets by using a rapid investigative tool for counterfeit detection [42]. Near-infrared (NIR) spectroscopy was used as a quick and easy analytical approach to distinguish fake pharmaceuticals. Atorvastatin calcium sesquihydrate (AT) formulations were found in seven different types of brand-name and generic pills. The likelihood of classifying the AT tablet samples into the seven kinds was 100%. The major excipient combinations were what determined the PCA and SIMCA (Soft independent modeling of class analogy) classification of the AT tablets [43]. From the related work we studied and analyze the hyperspectral imaging technology that is used most to identify fake medicines and active pharmaceutical ingredients (API) with an average spectral range is 450nm to 1000nm. We also analyze the fake medicine tablets that are found in internet pharmacies and medicines stores those are Paracetamol, Pfizer Viagra, Plavix, and Cialis.

III. DATA COLLECTION TECHNIQUES

The issue of medicines has evaluation has significantly across the globe. The importance and difficulty of maintaining medical performance are increasing. This creates demand for faster, smarter ways to meet demand. Any medicine, pharmaceutical ingredient, or material is considered an active pharmaceutical ingredient. It's all about testing, testing for similar as compounds and identifying contaminants. Preparations of pharmaceuticals medicines can be analyzed using various tools or methods.

A. Spectroscopic Method

The word spectroscopy describes a variety of techniques that make use of radiation to learn more about the composition and characteristics of substances. Spectroscopy refers to a wide range of technologies that employ radiation to collect information about the composition and features of a material, which one used to tackle a wide range of research problems [44]. A variety of analytical issues can be resolved by using the spectroscopy approach, which studies the chemical and physical characteristics of materials using radioactivity. In the spectroscopic technique, there are different types of the spectroscope. In that Infrared spectroscopy (IRS) and near-infrared spectroscopy (NIRS), Mass spectrometry (MS), Nuclear magnetic resonance (NMR) spectroscopy, Raman spectroscopy, Fourier transform infrared (FTIR) spectroscopy, etc. For example, NIRS has been widely used in the pharmaceutical sector, to identify crude ingredients or Active Pharmaceutical Ingredients (API), or to determine relative humidity. NIRS collects details about both chemical and physical factors. The biologically active component of a drug product (tablet, capsule, cream) that produces a better impact is referred to as the active pharmaceutical ingredient (API) [45]. Raman spectroscopy, which is simple, non-destructive, and information-rich, is an excellent method for the detection of the rapid categorization of drug substances. It provides a powerful tool for the analysis and determination of counterfeit medicines when coupled with chemometric techniques [46].

B. Chromatographic Method

The chromatography method can be utilized for and separate the components within a mixture. It is a process used in laboratories to separate mixtures. The mixture is dissolved in a fluid known as the mobile phase, which transports it through a structure that contains another substance known as the stationary phase. Chromatography can be used for both preparatory and analytical purposes. Preparative chromatography is a type of purification that is used to separate the components of a mixture for later use. Analytical chromatography is often employed for lesser amounts of material, although it may also be utilized for pharmaceutical analysis and formulation. Chromatography may be used for purification and classification, it is a method that use in laboratories to separate mixtures.31 For the identification of fake medications and illicit pharmaceutical formulations, many chromatography methods have been used and are as following [47].

C. Thin-layer Chromatography

Thin-layer chromatography (TLC) is a method that has the benefits of being inexpensive and simple to use. The basic idea behind TLC in counterfeit analysis is straightforward: by comparison of the results with a test solution that was similarly applied to a TLC silicon plate, the existence or authenticity of the active ingredient in a fake or copycat sample is verified.

D. Liquid Chromatography

It is utilized in the evaluation and characterization of unlawful pharmaceutical formulations and fake medications. LC is utilized in this sector for a variety of reasons in conjunction with various detectors. It is used as both a quantitative approach and a method for target analysis (the presence of one or more recognized substances).

E. Gas Chromatography

Gas chromatography (GC) have been employed to identify and find fake medications. Gas chromatography has been used to verify the authenticity of essential oils and the presence of residual solvents, volatile components, and unidentified chemicals or analogues (particularly in the quality assurance of herbal remedies) [48].

F. Hyperspectral Imaging Method

Hyperspectral imaging (HSI) is a developing imaging technique for use in medicine, particularly in the detection of illness with photograph treatment. The hypercube collection, which has three dimensions two geographical and one spectral is acquired via HSI. HSI's remotely sensed spectrum scanning yields sensor readings on the biology, and architecture, including the substance of the material. Hyperspectral imaging is a blended technique that integrates spectroscopic with image processing. The three-dimensional (3-D) dataset of spatial and spectral data is produced through Hyperspectral imaging besides gathering spectral information at each pixel of a two-dimensional (2-D) sensor emits. This set of information is referred to as a hypercube. Figure *1* Hypercube versus red, green, and blue picture comparisons. The two-dimensional picture on every wavelength is a part of the three-dimensional database known as Hypercube. The reflectance curve (spectral signature) of a pixel in the picture may be located in the lower left. Merely 3 picture bands on the red, green, and blue wavelengths are present in an RGB color picture. The RGB picture's image pixel gradient is shown in the bottom right. The source of each spectrum on samples may be identified with geographical information, allowing for a more thorough investigation of how light interacts with the disease. HSI can recognize several pathological disorders thanks to the spectral signature of each pixel in the photos. In comparison to multispectral imaging (like red, green, and blue color cameras), HSI often covers a continuous region of the visible spectrum with more spectral bands (more than hundred) and greater spectral resolution [49]. Over the past years, hyperspectral imaging methods have successfully demonstrated their value in a variety of pharmacological research domains. It involves taking pictures of an object at several distinct wavelengths.

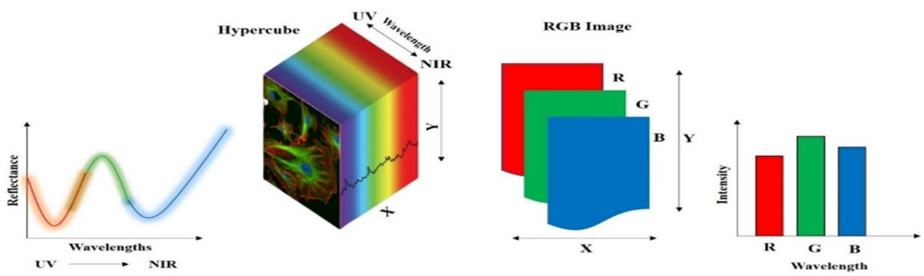

Figure 1:Hypercube 3D dataset and RGB 2D Images

A hyperspectral picture is essentially a datacube with 2 dimensions that reflect spectral wavelengths. Hyperspectral imaging is used in chemical imaging, which is the process of identifying and quantifying the chemical components of a sample or product, as well as their dispersal or uniformity. Compared to hyperspectral imaging, which covers any frequency band, spanning visual to lengthy infrared, chemical imaging generally uses the near-infrared (NIR) or short-wave (SWIR) infrared ranges, which carry on the bases of the chemical relationships The NIR and SWIR spectra of the organic compounds which make up the majority of pharmaceuticals are distinctive. Chemical compositions inside a material can be identified and quantified using spectral features. Combining, tracking tablets manufacture, and spotting fake goods are just a few of the medical research and quality assurance applications that make utilization of chemical imaging.

IV. Hyperspectral Data Analysis

For the hyperspectral data collection and analysis below steps as in Figure *2* can be followed

A. Data Pre-processing

Images recognition and data standardization are the fundamental components of the hyperspectral imaging pre-processing stage. The literature additionally makes use of the Gaussian function to flatten spectral signatures and

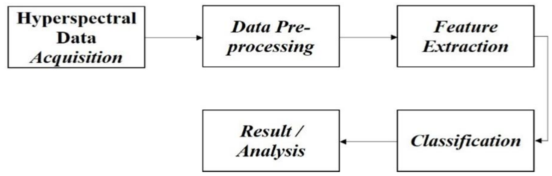

Figure 2:Workflow steps for proposed system

reduce the noise impact [50]. Data normalization modifies or normalizes hyperspectral illumination data to values that indicate the inherent characteristics of biomaterials, such as absorbance or reflectance. A superior way of preparing data for the analysis is by normalization, which also minimizes systems distortion and image artifacts caused by uneven surface illumination or a lot of unnecessary data in the hyperspectral imagery's sub-bands. Absorbance and reflectance [51,52] are the most popular pre-processing techniques used in hyperspectral data. By covering the sensor lens, taking a dark picture, and subtracting the hyperspectral data for the dark image. From the hyperspectral data taken from the area of interest, the camera's dark current impact was eliminated. To create a white reference image, a white diffuse reflectance target was employed. The hyperspectral data relative reflectance (R) is determined by equation 1. From the collected data it needs to select a spatial region of interest (ROI) and then apply further pre-processing [53].

$$R = \frac{Is - Id}{Iw - Id} \; x \; 100 \qquad (1)$$

whereas *I*d is the dark image, *I*w is the white reference image, and *I*s is the raw hyperspectral data.

B. Feature Selection and Feature Extraction

Finding the most pertinent information within the original dataset and representing it in a lower-dimensional space are the aims of feature selection and feature extraction. A greater variety of spectral bands may make it feasible to distinguish between more particular classes in hyperspectral databases. However, using too many spectral bands may reduce the accuracy of classification because of the effect of dimensionality. Every pixel in hyperspectral data may be expressed as an N-dimensional vector, where N is the total number of spectral bands. For hyperspectral image processing applications, such pixel-based format has been extensively employed [54].

C. Classification

Primary pixel and subpixel hyperspectral data categorization techniques utilized within the medical field depend on the type of pixel information present. Structured and unstructured categorization could be done at the pixel level. Sampling distribution for the data is typically assumed by parameterized classifications, however, this assumption is frequently ignored in applications [55].

Principal component analysis (PCA): PCA is the commonly utilized dimensionality reduction technique for analyzing medical hyperspectral datasets. While retaining the majority of the variation in the high-dimensional region as is practicable, PCA minimizes redundant information in the bands of hyperspectral imaging [56]. It is new platforms of remotely sensed have made utilization of the principle component analysis. A historical backdrop of PCA and its mathematical justification are detailed in Gonzalez and Woods in 1993. The overall majority of the research focuses on methods for achieving efficient multispectral data categorization, with little attention paid to PCA efficiency and also its enhancement. The principal component analysis is based on the observation that adjacent bands in hyperspectral imaging frequently include data about the object that is nearly identical and strongly correlated. The analysis is used to modify the original information to eliminate band correlations. The procedure results in the identification of the ideal linear function of a set of the original bands that accounts for the variance of pixel values in a picture [57]. Simply data dimensionality is reduced using the mathematical equation that is Principal Components Analysis (PCA). As a result, the PCA approach enables the recognition of standards in data and their representation in a way that highlights both their similarities and contrasts. Finding patterns, compressing them, and reducing their size without losing any information [58].

K-Nearest Neighbour (KNN): One of the simplest machine learning algorithms, depending on the supervised method, is K-Nearest Neighbour. A new data point is classified using the K-NN method groups with similar after all the existing data has been stored. As a result, fresh data may be quickly and accurately categorized into appropriate categories that use the K-NN algorithm, emphasizing both their distinctions and similarities. Finding patterns, compressing them, and reducing their size without losing information [59]. A popular non-parametric technique for classification in pattern recognition is the KNN algorithm. The core element of KNN is that a data point's categorization is decided by the classifications of its closest K neighbours [60].

Partial Least Square Regression (PLSR): It is frequently used for quantitative spectrum analysis as well as reflectance spectroscopic data processing. It breaks down both variables and discovers additional components. When there are several highly line segments key predictors, it is utilized to build forecasting analytics. Based on the spectrum, it may be utilized to create a linear prediction model for the sample size. Distinct frequency readings make up each spectrum. The answers are forecasted linearly using the PLS Factors, which are generated as a specific linear combination of the spectral range. Compared to the previous multiple regression approach method, it produces richer findings [61].

Support Vector Machine (SVM): The aims of SVM is to identify an ideal higher-dimensional space as a decision boundary in high-dimensional space, is founded on a statistical learning concept. The SVM chooses from an unlimited number of linear decision boundaries the one that minimizes the classification error in the instance of a two-class pattern-recognition problem when the categories are discrete. The decision boundaries chosen will therefore be the one that leaves the largest class label, where the margin is defined as the sum of the distances from the nearest instances of the two classes to the higher dimensional space [62,63]. Support vector machines' benefits include efficiency in high-dimensional environments. It is useful in situations where the quantity of dimensions exceeds the number of samples. It is also memory efficient since it only uses a portion of the training points (known as support vectors) in the decision function. There are standard processors available, but we can also define our processors. SVM has some drawbacks, including avoiding over-fitting when selecting processor functions and regularisation terms if the number of features is much more than the sample size [64].

V. Challenges

Currently, the areas of active pharmaceutical ingredient detecting (API), pharmaceutical validity authentication, medication cluster analysis, or medication covering layer recognition are used hyperspectral technologies in pharmaceuticals. The majority of pharmaceutical identification techniques like analytical methods, spectroscopy methods, and the basic principal component analysis (PCA), with partial minimal, when it comes to statistical techniques like polynomial regression (PLSR), data evaluation in the experiment is often the implementation situation; commercial pharmaceutical production processes, as well as other locations, are not excluded from this. As a result, there are many potential applications for hyperspectral technology in the context of pharmaceutical research, yet there are numerous obstacles to overcome. The main problem at the moment is how to employ hyperspectral technologies in medication identification in the commercial pharmacy setting using extreme accuracy and cheap cost. So continued development of that kind of technique is being constrained by a shortage of pharmaceutical hyperspectral data sources or a lack of scientific fervor. Hence, should ensure the continued development of hyperspectral technologies inside this sector, academics have to not only extend beyond identification techniques to generally utilized computer vision techniques, yet also need to regularly incorporate popular pharmacological detecting data.

VI. Conclusion

Based on the study, the issue of fake medications has indeed been extensively acknowledged, although it is not yet properly described and adequately handled. According to a study, we found the most fake pharmaceuticals medicines are antimicrobials, antimalarials, erectile dysfunctions, herbal, diabetes, and weight control. In this study, we have tried to provide an overview of several approaches for the identification of fake pharmaceutical medicines, particularly we are focusing on hyperspectral imaging technology because the is non-invasive, actual hyperspectral imaging technologies are three-dimensional picture cubes having 2-dimensional aspects, and one spectral aspect can be acquired. Every hypercube pixel may well be described by a spectral curve that really can reach from the Ultraviolet towards the Infrared spectrum. This hyperspectral imaging acquired remotely sensed spectrum offers analytical details on the material biology, architecture, including substance. As it gives spectrum data that could be utilized to differentiate between authentic and fraudulent medications, hyperspectral sensors easier processes thus accelerating the identification of falsified medicines as found 350 nm to 1000nm visible range to near-infrared range.

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