

Study on Digital Enhancement Using Image Processing and Pattern Recognition Techniques in Forensic Ballistics

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Abstract – The ascent in violations and the utilization of guns require ballistic and legal science research centers worldwide to concoct speedy and precise arrangements. The ID cycle of guns is a complex yet extremely touchy and essential advance in proof assessment during the time spent wrongdoing examination. The utilization of present day strategies like picture handling and example acknowledgment can add to build the precision just as lessen the time during the time spent ID. Physically, numerous highlights of a spent slug of a gun are examined for this reason, striations being a significant one of them. The point of the investigation is to naturally section out the striations present in a shot slug through picture preparing and division procedures, which is a genuine test as these imprints are fine. For the examination, pictures of two discharged shots of .22 in. type rimfire cartridge, discharged from indeed the very same gun (self-loader gun) were considered for the fundamental investigation. Trial results show that proposed strategies can be proficiently utilized for gun distinguishing proof through digitizing and examining the discharged projectiles examples. The visual examination uncovers that the Fuzzy C Means strategy gives the most clear sectioned aftereffect of the striations. This could be of extraordinary use later on as it is an efficient cycle. This can be of incredible assistance in highlight ID, opposite manual looking of the component under an examination magnifying lens for recognizable proof of the gun.

Keywords— Ballistic, Firearm Identification, Striations, Segmentation

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INTRODUCTION

The subject of ballistics has been read for quite a long time by individuals at each degree of scholarly accomplishment. A portion of the world's most noteworthy mathematicians and physicists like Newton, Lagrange, Bernoulli, and others tackled issues in math and mechanics that either straightforwardly or in a roundabout way was applied to the different ballistic controls. The field of ballistics can be extensively ordered into three significant orders: inside ballistics, outside ballistics, and terminal or wound ballistics (Donald et al., 2007). To address the difficulties presented by the counter friendly components, the study of Forensic Ballistics has been created generally. Extensively speaking, "Scientific Ballistics" is a part of Forensic Science, which covers the techniques for recognizable proof of guns and ammo to tackle the issues associated with shooting episodes in criminal examination. While "Ballistics" signifies the study of movement of shots, "Criminological" is equivalent to legitimate and is, subsequently, more proper in this unique situation. "Scientific Ballistics" was begat by Colonel Goddard in an article with that title composed for Army Ordnance in the year 1925. Gun assessment

completed in the Forensic Science Laboratories assumes a significant part in the criminal examination framework. Lawbreakers, fear based oppressors and assailants in this nation utilize a wide assortment of guns and ammo. Considering wide assortments of guns and ammo, the example of gun wounds is additionally profoundly factor. An appropriate comprehension of gun wounds with uncommon reference to their causation and curious attributes is of most extreme significance in the remaking of a shooting occurrence. Legal ballistics includes examination of shots and slug effects on decide data of utilization to a court or other piece of a general set of laws. Independently from ballistics data, gun and device mark assessments ("ballistic fingerprinting") include investigating gun, cartridge case slug, proof to build up whether a specific gun was utilized in the commission of a wrongdoing.

Firearm

A get together of a barrel and activity from which a shot is pushed by results of ignition. Current guns are regularly depicted by their drag breadth or type or measure, the sort of activity utilized (gag, breech, switch, bolt, siphon, gun, self-loader, or

programmed) along with the typical methods for department (hand-held or mechanical mounting). They might be additionally recognized by reference to the sort of barrel utilized (rifled) and the barrel length. The seized or suspected gun, which was utilized to perpetrate the wrongdoing were shipped off criminological research center stepping through examination discharge, for correlation of the shot striation mark.

Cartridge

A cartridge (likewise called a round or a shell) is a sort of ammo bundling a slug or shot, a charge substance (typically either smokeless powder or dark powder) and a groundwork inside a metallic, paper, or plastic case that is exactly made to fit inside the discharging office of a gun (Sparano, 2000).

Cartridge Case Head Stamp Mark

A head-stamp is the markings on the lower part of a cartridge case intended for a gun. It generally tells who fabricated the case. On the off chance that it is a regular citizen case it frequently additionally tells the type: in the event that it is military, the time of production is frequently added. The head-stamp is punched into the foundation of the cartridge during produce. Military cartridge head-stamps don't normally have the type and cartridge name on it. The head-stamp may have a 2-or 3-image letter, number, or alphanumeric code demonstrating the spot of assembling (Sharpe, 1953). This is generally trailed by two digits demonstrating the last two digits of the time of production. Mid twentieth century cartridges may have extra digits or a letter demonstrating the period of production.

Examination of Ballistic Specimens

At the point when a gun is released, the weapon barrel leaves striation mark on the outside of the shot and the firearm's discharging pin, breech face, and ejector engrave the slug packaging with unmistakable markings. These markings contain a "shot mark" and a "packaging mark" that are viewed as remarkable to every gun. The troubles related with conventional imaging of ballistics examples are various, and incorporate the more modest example measures, the idea of the surfaces and states of the cartridge cases and shots.

The measurable assessment of ballistics examples depends on the identification, acknowledgment and extreme coordinating of markings on the surfaces of cartridges and shots made by the guns (Bernstein et al., 1975). Conventional techniques for the correlation of these imprints depend on episode light microscopy. The picture shaped from the diagonal light of the imprint gives are show of the outside of the example in the area of the imprint (Buchanan 1979). This portrayal is fundamentally subject to the material of the surface, on which the imprints have

been made, and the calculation and force of the enlightenment framework. The evaluation by the ballistic master of the similitude between tantamount imprints on separate ballistics examples from crime locations and test firings will be founded on the mastery and experience of the technologist. Along these lines the conventional technique for coordinating with markings has innate troubles, while keeping a component of subjectivity (Lillesand and Kiefer, 1980). The recognizable proof of the ballistics example from the crime location with the test example is customarily directed by planning the imprints by visual pictures from a low-controlled optical magnifying lens.

The choice of highlights inside the recognizing mark is picked for their evident uniqueness trying to coordinate with both crime location and test examples. A choice is made whether a similar gun was answerable for making the imprints under assessment on the crime location and test ballistics examples. The determination of the imprint or set of imprints for assessment and examination is a basic advance in the distinguishing proof interaction, and has the ability to impact ensuing stages in the correlation cycle (Loeve, 1955). The challenges related with customary imaging of scientific ballistics examples are various, and incorporate the more modest example measures, the idea of the surfaces for the cartridge cases (metal) and shots (lead) where highlights have low difference, the round and hollow state of the cartridge cases, and the twisted states of the shots (in the wake of striking items). Customary ballistics ID utilizing ordinary low controlled comparator microscopy assessments of scientific ballistics examples is a work serious movement with a little while of time being given to a solitary investigation and correlation. Computerized picture handling frameworks not just can possibly lessen this period for ID to a few hours however it additionally learn the better representation of the example for positive recognizable proof with an extraordinary accuracy. A grounded imaging framework will both rapidly pay for its innovative work costs, and furthermore gives fast reaction by police at a crime location occurrence.

A couple of frameworks for gun distinguishing proof have been created around world. These incorporates DRUGFIRE (Moik, 1980), created by Federal Bureau of Investigation, USA, IBIS (Sabbins, 1986), created by Forensic Technology, a division of the Walsh Group, and The Fireball Firearm Identification System created after the underlying exploration directed by Smith, Cross and ECU programming group (Swain and Davis, 1978). These frameworks incorporate advanced imaging, data set and systems administration advances to upgrade the capacities of the measurable gun inspector. At the point when a gun is stacked and shot, the components and parts of the gun that comes into contact with the cartridge case or shot reason striations and impressions that are considered as a ballistics signature. Studies have

shown that no two guns, even those of a similar make and model, will create similar one of a kind marks on shot projectiles and cartridge cases (Li and Watson, 1998) the estimation of these highlights permits exact ballistics measurements to be gotten for the ID of the make and model of the gun. The IBIS-BRASSTRAX-3D gives various quality control highlights like a robotized procurement plate, computerized imaging for breech face and terminating pin impressions, and mechanized lighting, center, and framework alignment. The positive distinguishing proof of Exhibits/ballistics examples from imaging frameworks is a significant utilization of innovation in criminal examination. While the picture catch philosophy for individual and examples is comparative, the interaction of distinguishing proof for each is subject to the degree of conviction needed for the ID and understanding.

Introduction to Digital Image Processing

An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows.

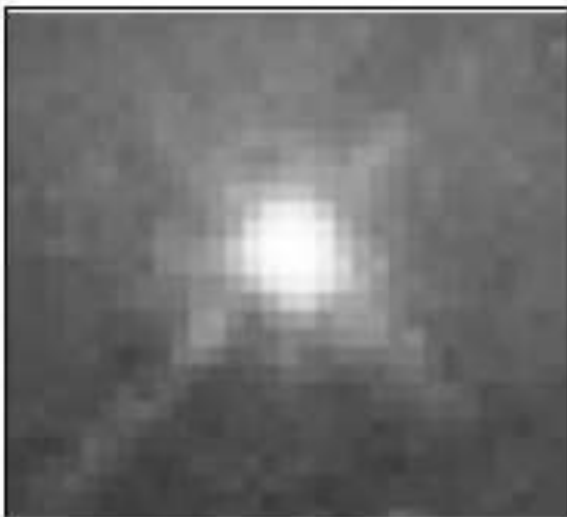


Figure 1.1: An image- an array or a matrix of pixels arranged in columns and rows.

In a (8-bit) greyscale image each picture element has an assigned intensity that ranges from 0 to 255. A grey scale image is what people normally call a black and white image, but the name emphasizes that such an image will also include many shades of grey.

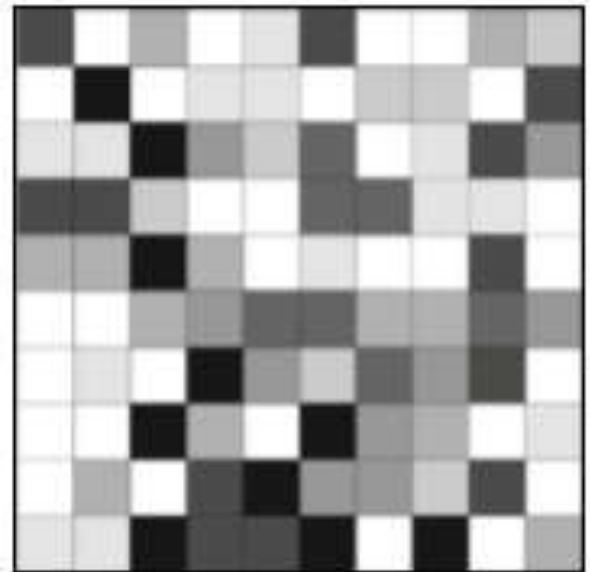


Figure 1.2: Each pixel has a value from 0 (black) to 255 (white). The possible range of the pixel values depend on the colour depth of the image, here 8 bit = 256 tones or greyscales.

A normal greyscale image has 8 bit colour depth = 256 greyscales. A “true colour” image has 24 bit colour depth = $8 \times 8 \times 8$ bits = $256 \times 256 \times 256$ colours = ~16 million colours.



Figure 1.3: A true-colour image assembled from three greyscale images coloured red, green and blue. Such an image may contain up to 16 million different colours.

Some greyscale images have more greyscales, for instance 16 bit = 65536 greyscales. In principle three greyscale images can be combined to form an image with 281,474,976,710,656 greyscales. There are two general groups of ‘images’: vector graphics

(or line art) and bitmaps (pixelbased or 'images'). Some of the most common file formats are:

- GIF — an 8-bit (256 colour), non-destructively compressed bitmap format. Mostly used for web. Has several sub-standards one of which is the animated GIF.
- JPEG — a very efficient (i.e. much information per byte) destructively compressed 24 bit (16 million colours) bitmap format. Widely used, especially for web and Internet (bandwidth-limited).
- TIFF — the standard 24 bit publication bitmap format. Compresses non-destructively with, for instance, Lempel-Ziv-Welch (LZW) compression.
- PS — Postscript, a standard vector format. Has numerous sub-standards and can be difficult to transport across platforms and operating systems.
- PSD – a dedicated Photoshop format that keeps all the information in an image including all the layers.

Colors

For science communication, the two main colour spaces are RGB and CMYK.

RGB

The RGB shading model relates near the manner in which we see tone with the r, g and b receptors in our retinas. RGB utilizes added substance shading blending and is the essential shading model utilized in TV or some other medium that tasks tone with light. It is the essential shading model utilized in PCs and for web illustrations, yet it can't be utilized for print creation. The optional shades of RGB – cyan, maroon, and yellow – are framed by blending two of the essential tones (red, green or blue) and barring the third tone. Red and green join to make yellow, green and blue to make cyan, and blue and red structure red. The mix of red, green, and blue in full force makes white. In Photoshop utilizing the "screen" mode for the various layers in a picture will make the forces combine as one as per the added substance shading blending model. This is practically equivalent to stacking slide pictures on top of one another and focusing light through them.

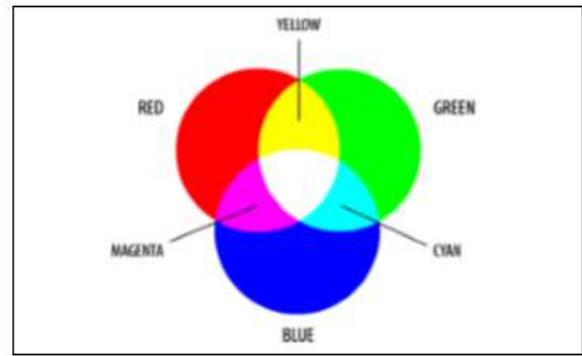


Figure 1.4: The additive model of RGB. Red, green, and blue are the primary stimuli for human colour perception and are the primary additive colours. Courtesy of adobe.com.

CMYK

The 4-colour CMYK model used in printing lays down overlapping layers of varying percentages of transparent cyan (C), magenta (M) and yellow (Y) inks. In addition a layer of black (K) ink can be added. The CMYK model uses the subtractive colour model.

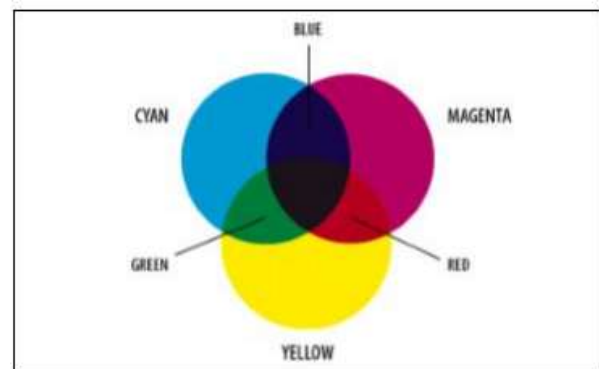


Figure 1.5: The colours created by the subtractive model of CMYK don't look exactly like the colours created in the additive model of RGB. Most importantly, CMYK cannot reproduce the brightness of RGB colours. In addition, the CMYK gamut is much smaller than the RGB gamut. Courtesy of adobe.com.

Advanced Image Processing (DIP) includes the change of computerized information for improving the picture characteristics with the guide of PC. The handling helps in amplifying clearness, sharpness and subtleties of highlights of revenue towards data extraction and further investigation. Advanced picture handling is a wide subject and regularly includes methods which can be numerically unpredictable, yet focal thought behind computerized picture preparing is very straightforward. The computerized picture is taken care of into a PC and PC is customized to control these information utilizing a condition, or arrangement of conditions and afterward store the aftereffects of the calculation for every pixel (picture

component). These outcomes structure another advanced picture that might be shown or recorded in pictorial configuration or may itself be additionally controlled by extra PC programs/software's. The potential types of the computerized picture control are in a real sense boundless. The crude computerized information when seen on the showcase will make it hard to recognize fine highlights. To specifically improve certain fine highlights in the information and to eliminate certain commotion, the advanced information is exposed to different picture preparing activities. Picture preparing strategies might be assembled into three useful classes: these are characterized underneath along with arrangements of commonplace handling procedures. Picture Enhancement right the visual effect that the picture has on the mediator in a style that improves the data substance, for example, (a) Contrast, Intensity, tint, and immersion (b) separating of commotion and (c) Edge upgrade/recognition and so on.

REVIEW OF LITERATURE

Geradts et. al. (2013) portrays the different strategies for highlight choice and example acknowledgment utilized in the examination method. For the pictures to be thought about naturally, the valuable pieces of the pictures should be separated. Here, a correlation was made of a few preprocessing steps on data sets pictures.

Bijhold and Geradts (2014) depicted the utilization of, picture handling and example acknowledgment in measurable distinguishing proof of different piece of information materials.

Rosiak (2011) talk about the similar investigation of computerized and minute assessment of gun recognizable proof. The essential measure for the evaluation of execution of ballistic investigation frameworks is the characterized time needed for a "hit" to be gotten, for example the connecting of a gun to a wrongdoing. These hits might be gotten all the more rapidly if a uniform assessment scale is utilized to decide properties and distinguishing proof prospects of analyzed material. Human dynamic might be sped up by the use of PC based innovation, for example, picture and data handling, to this interaction. Regardless, in any case, the outcomes got utilizing a particularly robotized ballistic distinguishing proof framework should in any case be affirmed by a guns inspector utilizing an examination magnifying lens.

Bijholda (2001) proposed that models for highlight determination in spite of the fact that market a few frameworks exist for gathering spent ammo information for measurable examination. These information bases store pictures of cartridge cases and the imprints on them. Picture coordinating is utilized to make hit records that show which marks

on a cartridge case are generally like another cartridge case. The exploration in this paper is centered around the various techniques for highlight determination and example acknowledgment that can be utilized for upgrading the consequences of picture coordinating.

Smith (2001) depicted advancement in the improvement of a multidimensional bunch investigation model for measurable ballistics examples. The group examination will give order that depends on scalar shape and estimation boundaries for the 3D highlights of class attributes. The choice of fitting class qualities for and shot can be planned in N-dimensional space to give grouping to specific weapon types. By planning the crime location example to the multidimensional ballistics information, the chance of a counterpart for ID can be accomplished

Mazumdar et. al., (2002) decided a slug cartridge mechanized recognizable proof framework dependent on conventional underlying and representative properties of a head stamp and the nonexclusive boundaries (bore, type and so forth) in view of basic item enrollment and coordinating with strategy.

Li (2003) portrayed the challenges related with customary imaging of ballistics examples are various, and incorporate the diminutiveness of the examples, the idea of the surfaces and shapes for the cartridge cases and shots. The "mechanical finger impression" on discharged slugs and cartridge cases can be utilized to recognize the gun that they went through. A PC based gun distinguishing proof framework, Fireball, has been created at Edith Cowan University and utilized by police ballistics segments in Australia. This paper will give a concise depiction of this framework and subtleties of the picture handling like division, include extraction and picture preparing prior to saving pictures to the picture information base.

Pascucci (2006) introduced the old style strategies for design acknowledgment and a novel plan to appraise the similitude between two arrangements of n-dimensional focuses. Indeed, there are not known answers for this issue. To assess how much comparable two datasets are, it is important to acquaint a few strategies with ascertain the distance between them. We propose the utilization of likelihood thickness capacities as descriptors of datasets and the assessed distance between two focuses as the proportion of the distance between the two related sets, Patterns are what we need to search for over our information.

OBJECTIVE

1. Digital Enhancement of Cartridge Case Head Stamp mark by application of image

processing and pattern recognition techniques.

- Digital Enhancement of Bullet Striation Mark by application of image processing and pattern recognition techniques

RESEARCH METHODOLOGY

Processing of the Digital Images

The Cartridge Case Head Stamp Mark and Bullet Striation Mark pictures were first prepared with Median and High Pass channels in a consecutive way to diminish the commotion. Hence the pictures will go through for shading change and Histogram Equalization. The handling was finished by the picture preparing tool compartment "Corel Paint Shop Pro Photo X2". To approve the outcomes accomplished by Image handling tool compartment "Corel Paint Shop Pro Photo X2", we likewise practice another comparative sort of Image preparing programming for example Adobe Photoshop 7.0 in the current examination to reconfirm the outcomes.

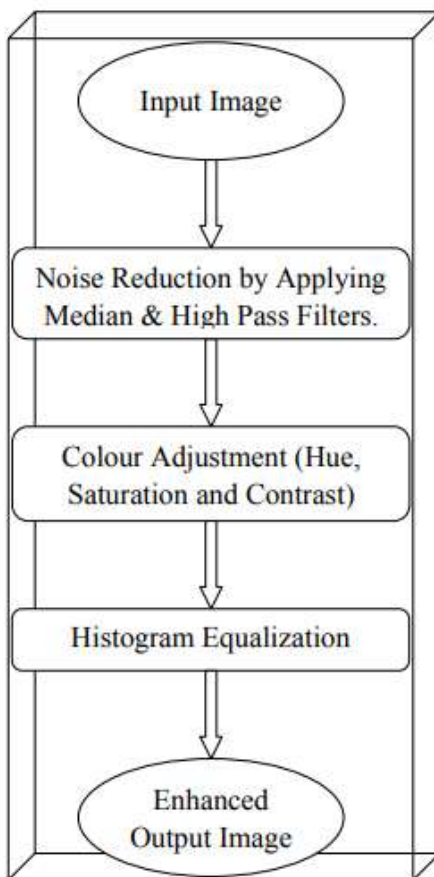


Figure 1.1: Flow Chat for Image processing

RESULTS AND DISCUSSION

The current investigation the procedure utilized for upgrade of Cartridge Case Headstamp Mark and Bullet Striation Mark pictures, clearly improve the lucidity and diminishes commotion by utilizing the

utilization of Image handling tool compartment "Corel Paint Shop Pro Photo X2". To approve the outcomes accomplished by Image preparing tool compartment "Corel Paint Shop Pro Photo X2", we practice another comparative kind of Image handling programming Adobe Photoshop 7.0 in the current examination

Noise Reduction by Median Filter:

Advanced pictures are uproarious because of biological aggravations and it is corrupt the nature of pictures. Informational indexes gathered by picture sensors are for the most part contaminated by commotion and it is because of blemished instruments/obtaining framework. The clamor is portrayed by its example and by its probabilistic attributes. To eliminate the commotion, for example, Salt-and-Pepper Noise we applied Median Filter in the current investigation. The middle channel scans the range of a pixel choice for pixels of comparative splendor, disposing of pixels that vary a lot from contiguous pixels, and replaces the middle pixel with the middle brilliance worth of the looked through pixels. This channel is helpful for wiping out or decreasing the impact of clamor on a picture. The customizable boundary for the middle channel is the size of the area utilized. Commotion decrease relies on the utilization of neighborhood size which is adequately little to hold genuine subtleties, and to rehash the activity a few times. The middle channel range esteem on 1.0 to 2.0 creates great quality clamor free pictures (Figure 1.2 and 4.3). The significant benefit of Median separating is a nonlinear strategy used to eliminate commotion from pictures. It is broadly utilized as it is compelling at eliminating commotion while safeguarding edges. It is especially powerful at eliminating 'Salt and Pepper' type commotion. The middle channel works by traveling through the picture pixel by pixel, supplanting each worth with the middle benefit of adjoining pixels. The example of neighbors is known as the "window", which slides, pixel by pixel over the whole picture pixel, over the whole picture. The middle is determined by first arranging all the pixel esteems from the window into mathematical request, and afterward supplanting the pixel being considered with the center (middle) pixel esteem.

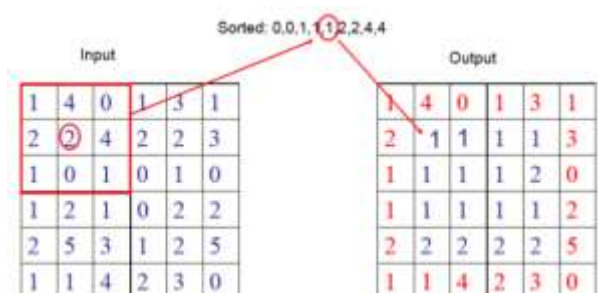


Figure: 1.2 Median Filtering using 3 X 3 Sampling windows of a segment.

The results in term of Median Value and Pixel Count, after applying the median filter on the test images are given in Table 4.1 and Table 4.2.

Table: 1.1: Median Value and Pixel Count after applying Median Filter on Cartridge case Head Stamp Mark images.

Test Image No.	Median Value		Pixel Count	
	Before	After	Before	After
S1	94	156	65536	65536
S2	100	144	63488	63488
S3	132	178	61440	61440
S4	135	180	53502	53502
S5	109	166	47925	47925
S6	108	141	56168	56168
S7	156	154	53550	53550
S8	157	197	63488	63488
S9	112	171	61440	61440
S10	102	168	57856	57856
S11	209	232	53040	53040
S12	105	171	52998	52998
S13	97	156	55404	55404
S14	175	198	63488	63488
S15	77	123	61440	61440
S16	215	240	53502	53502
S17	201	223	63488	63488
S18	140	201	53040	53040
S19	128	178	57856	57856
S20	177	223	47925	47925

CONCLUSION

The Image preparing tool compartments for example "Corel Paint Shop Pro Photo X2", Adobe Photoshop 7.0 and Matlab 2011a are condition of craftsmanship apparatus having exceptionally compelling improvement calculations for cartridge case head stamp imprint and slug striation pictures. Computerized picture handling assumes a crucial part in upgrade of low quality pictures. Particularly information acquired from Automated Image Acquisition Systems, which is in the computerized structure, can best be used with the assistance of advanced picture preparing. Picture upgrade is a significant segments of advanced picture Processing. Picture improvement methods help in improving the perceivability of any segment or highlight of the picture stifling the data in different segments or highlights. The point of picture upgrade is to improve the visual appearance of a picture, or to give a "superior change portrayal for future computerized picture handling". Separated of Forensic pictures relates to different controls numerous pictures like clinical pictures, satellite pictures, minuscule pictures and surprisingly genuine photos experience the ill effects of helpless differentiation and commotion. It is important to upgrade the difference and eliminate the commotion to expand picture quality. Picture Enhancement procedures improves the quality (clearness) of pictures for human survey just as for machine understanding, eliminating obscuring and commotion, expanding differentiation, and uncovering subtleties are instances of upgrade activities. The improvement strategy varies starting with one field then onto the next as indicated by its target. Nonetheless, this present programming's requirements a decent PC which has high determination with the goal that the preparing for the picture is proficient.

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