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The value of NVR (Network Video Recorder) as a helping hand in criminal investigation

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Abstract
The purpose of this paper is to understand the available closed circuits television available for the purpose of surveillance and to choose the best options to fulfil the higher requirements by providing the best in features that could provide better evidence during an investigation procedure.
The main purpose of this paper is to detect the weakness of the digital video recorder technology though which is cost effective but the amount of data provided is ineffective and to highlight the features of network video recorder the successor of DVR which would cover its shortcomings thereby providing higher degree of functionality.
The end goal of this project was a fully working wireless network, with appropriate hardware chosen for this task and better video surveillance ensuring security in most vital points.

Keywords: DVR, NVR, crime rates, investigation

1. Introduction
1.1 What is CCTV?
Closed circuit television (CCTV), also known as video surveillance, is the use of video cameras to transmit a signal to a specific location, on a limited set of screens. It differs from broadcast television in the sense that the signal is not broadcast openly, although it can be used as point-to-point (P2P), point-to-multipoint (P2MP), or cable or wireless connections. Although nearly all video cameras conform to this definition, the term is often applied to those used for surveillance in areas where additional security or constant monitoring is required.
Public surveillance using CCTV is common in many regions of the world. In recent years, the use of body cameras has been introduced as a new form of surveillance, often used in law enforcement, with the cameras on the chest or head of a police officer. Video surveillance has raised a lot of controversy over the balance between its use and people's right to privacy, even in public places.
When we talk about CCTV, it is mainly divided into two categories, DVR and NVR.

1.2 What is a DVR?
A digital video recorder (DVR) is an electronic device that records video in a digital format on a disk drive, USB flash drive, SD memory card, SSD, or a local or network attached large storage device. The term includes set-top boxes with direct-to-disc recording, portable media players, television portals with recording capability, and digital video cameras. Personal computers are often connected to video capture devices and used as digital video recorders; in such cases, the application software used to record the video is an integral part of the DVR. Many DVRs are classified as consumer electronic devices; these devices may alternatively be referred to as personal video recorders (PVRs), particularly in Canada. Similar small devices with built-in displays (approximately 5 inches in diameter) and SSD support can be used for professional film or video production, as these recorders often do not have the limitations of built-in cameras, providing broader encoding support, removing time constraints the registry and bitrates are higher.

1.2.1 Applications
a. Security: DVRs configured for physical security applications record video signals from closed circuit television cameras for detection and authentication purposes.

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Many are designed to record audio as well. DVRs have evolved into feature-rich devices that provide services that go beyond the simple recording of video images previously made through video tape recorders. The CCTV DVR system provides many advanced functions via VCR technology including video searches by event, time, date and camera. There is also greater control over quality and frame rate allowing for optimization of disk space usage and the DVR can also be set to overwrite the oldest security footage if the disk becomes full. In some DVR security systems, security footage can also be accessed remotely using a computer by connecting the DVR to a LAN or the Internet. Some of the latest professional DVRs include video analytics firmware, to enable functions such as "virtual flight wire" or even the detection of discarded objects in a scene.

1.2 Hardware features
Hardware features of security DVRs vary between manufacturers and may include but are not necessarily limited to:
Designed for rack mounting or desktop configurations.
Single or multiple video inputs with the types of connectors compatible with the analog or digital video provided such as coaxial cable, twisted pair or fiber optic cable. The most common number of inputs is 1, 2, 4, 8, 16 and 32. Systems may be configured with a very large number of inputs by networking or buses individual DVRs together.
The video output frequency for each input repeats the connector type and the corresponding video input signal. These output signals are used by other video devices such as matrix switches, multiplexers, and video displays.

b. Controlled outputs to external video display monitors
Front panel switches and indicators that allow the various features of the machine to be controlled.
Network connections consistent with the network type and utilized to control features of the recorder and to send and/or receive video signals.
Connections to external control devices such as keyboards.

c. Software features
Software features vary between manufacturers and may include, but are not limited to:
Image capture rates that the user selects either on a per-input or input-on-input basis. The pickup rate feature can be programmed to automatically adjust the pickup rate when an external alarm or an internal event occurs.
Selectable image resolution either on an all-input or input-by-input basis. The image resolution feature can be programmed to automatically adjust image resolution when an external alarm or internal event occurs.
Compression methods determine the quality of playback. H.264 hardware compression provides fast online transfer rates with high quality video.
Motion Detection: Provided on an input-by-input basis, it detects motion in the overall image or in a user-definable part of the image and usually provides sensitivity settings. Detection causes an internal event that may be caused by an external device and/or used to cause changes to other internal features.
No motion detection. This feature, provided on an input-by-input basis, detects the movement of the object in the field of view and remains constant for a time that the user can select. Detection causes an internal event that may be

caused by an external device and/or used to cause changes to other internal features.
Motion detection direction. This feature is provided on an input-by-input basis, and it detects the direction of movement in the image that the user has identified as an unacceptable event. Detection causes an internal event that may be caused by an external device and/or used to cause changes to other internal features.
Route video input to video screens based on user input or automatically on alarms or events.
Input, time and date stamp.

1.3 Pros of DVR technology
- Less expensive than NVR systems.
- Simplicity, easier to set up and operate than NVR systems.
- Image quality is improving (for systems using HD over Coaxial technology).

1.4 Cons of DVR technology
- Lower frame rates and lower image quality than NVR systems.
- Requires extra cables and wires, more complex installation process.
- Separate power source required.
- Less coverage, it takes multiple analog cameras to cover the same area as 1 IP camera.
- Only good for observing, can't record audio.

In this paper, we propose a sound argument for the utilization of NVR (Network Video Recorder) at crucial junctions in public places, to reduce the crime rates as well as improve the public welfare. We would be contesting in favour of adapting NVR & its relating technologies arguing for their benefits against the cost of such equipment. We would demonstrate statistics of improved security for areas where such technology is adopted.

2. Objective
The objective of this paper is to demonstrate the importance of adopting technologies as soon as possible thereby improving public welfare & safety. In this instance we would be taking the example of NVR and will be presenting its comparison with its predecessor DVR.
We would present the comparison on aspects mentioned below:
- Technological aspect.
- Crime Rate impact.

Based on the three criteria we would be contesting for the effectives of adopting the said technology and the increased efficiency in the police work.

3. Research methodology
A CCTV system is an integral part of the security measures that may need to be adopted by an organization. Institution premises may need to be monitored on a regular basis to ensure safety. Closed circuit television involves the use of video cameras to transmit a signal to a specific location on a limited set of screens. It differs from broadcast television in which the signal is not transmitted overtly. Despite this, almost all video cameras fit this definition.
The term is often applied to those used for surveillance in areas that may need surveillance such as banks, casinos,

airports, military installations, and stores. There are different types of CCTV systems: they include; Analog and digital, wired and wireless have different ways of operating. The basic components are more or less the same: a camera, a lens, a monitor, and cables (for wired systems) that transmit the signal from one place to another.

Many systems also use video recorders to record video footage. The camera picks up the signal from the area monitored through the lens (which determines how far and how far the camera can see, often purchased separately) and it can be wired or wireless.

In a wired system, the camera sends the signals via a cable to the monitor. In wireless systems, no cable is required, and the camera broadcasts the signal directly to the screen. The monitor can be either a simple TV (without capacitive tuning), a PC (PC) or a laptop. Most wired analog systems use television screens, while digital and wireless systems tend to use computers as monitors that can be viewed remotely, often over the Internet.

For recording purposes, the monitor is accompanied by a video recorder or video cassette recorder (VCR) for analog systems or a digital video recorder (DVR) or network video recorder (NVR) for digital systems.

In industrial facilities, CCTV equipment may be used to monitor parts of the process from the central room, for example when the environment is not conducive to humans, the CCTV system may operate continuously or only as required to monitor a specific event.

The CCTV system helps monitor areas that require security around the clock, helps monitor and control (human) traffic, prevents theft/theft, theft and other crimes, helps identify and initiate legal action against violators, and triggers alarms when approaching risks or circumstances that can be avoided. A proper CCTV system must justify its expenses and meet appropriate security requirements.

a. Video surveillance systems
A video surveillance system is also known as a closed circuit television (CCTV) system using video cameras to transmit a signal to a specific location on a limited set of screens.

The main components of every CCTV system are:
- Not connected.
- Multiple cameras, recorder and screen.

CCTV systems are broadly divided into two well-known types, namely:
- Wired CCTV Systems.
- Wireless surveillance camera systems.

Wired CCTV systems
You connect the camera to the recording device and the monitors with the help of standard coaxial cables, unshielded twisted pair (UTP) or fiber optic cables.

Wired CCTV systems provide the best picture quality without any interference, the camera can be placed hundreds of meters away from recording or monitoring equipment and all of its sensors can be powered from a single power source.

This system is the preferred choice when good image quality and economic gain considerations are required. However, system cabling and installation can be a tedious task that requires expert help, the system is fixed in a certain area and the camera cannot be moved easily to another location and wireless cameras are relatively expensive.

Wireless CCTV system
It consists of a wireless camera connected to a recording device and a monitor. This system is the preferred choice in specific locations without easy cabling facilities and for individuals who require an easy-to-install solution.

The wireless CCTV system camera is portable, cost effective and can be moved to other locations where monitoring is required. The system is best suited for sites that require temporary monitoring or on a temporary site.

Its camera can be hidden to detect theft or theft and the recording and monitoring device does not need to be in the same line of sight allowing monitoring of any place from another remote location. However, the system requires a dedicated frequency to transmit signals from the camera to the receiving and recording station.

Its frequencies may be subjected to various interruptions by the use of products powered by electric motors, air conditioning, fluorescent lighting or cordless telephones, which affects the image quality. Their camera may not provide the best image quality because these systems are prone to image distortion and require special wireless technology expertise to diagnose and fix system malfunctions.

b. Applications
In its broadest sense, the purpose of an enhanced Close Circuit Television video surveillance system in any security plan is to provide far eyes to the security operator in order to create live shows from a distance. The video system contains recording media: a VCR, DVR, or other storage media to keep permanent records of training or evidence. Here are some of the applications for which video provides an effective solution:

1. When overt visual observation of a scene or activity is required from a remote location.
2. Secret surveillance of the scene. It is easier to hide a small camera and lens in a target location than to put a person in the area.
3. There are few actions to monitor in the area, such as at an intrusion detection site or storage room, but important events in the area should be recorded as they occur.
4. The integration of video with alarm sensors and a time-lapse/real-time VCR or DVR provides a very powerful solution.
5. Many sites must be monitored simultaneously by a single person from a central security site.
6. Tracking a person or vehicle from an entrance to a facility to a final destination. Security forces can then predict where the person or vehicle may be intercepted.
7. Oftentimes a guard or security officer should only review a scene of activity periodically. Using video eliminates the need for a ranger to take tours to remote locations, wasting ranger time.
8. When the crime has not been committed, it is possible to capture the scene using a video camera and recorder to obtain a permanent record and hard copy of the activity and event.

c. Hardware components of a video surveillance system
Some of the hardware components used in a video surveillance system include:

1. **Lens:** light from the illumination scene reflects off the scene. The lens collects the light from the scene and forms an image of the scene on the light-sensitive camera sensor.
2. **Camera:** The camera sensor converts the visible scene formed by the lens into an electrical signal suitable for transmission to the remote monitor.
3. **Transmission link:** The transmission media carries the electric video signal from the camera to the remote monitor. Hard-wired media choice includes:- Coaxial, 2-wire Unshielded Twisted Pair (UTP), Fiber-optic cable, Local Area Network (LAN), Wide Area Network (WAN), Internet network. While, wireless choice includes: Radio Frequency (RF), Microwave and optical infrared signals can be analogue or digital.
4. **Monitor:** The video monitor or computer screens display (Cathode Ray Tube (CRT), Liquid Crystal Display (LCD) or Plasma) and the camera image by converting the electrical video signal back into a visible image on the monitor screens.
5. **Recorder:** Camera scene is permanently recorded by a real-time or time lapse VCR onto magnetic tape cassette or by a DVR using a magnetic disk hard drive.
6. **Hard-copy printer:** The video printer produces a hard copy paper printout of any live or recorded video image, using thermal, inkjet, laser or other printing technology.
7. **Camera switcher, quad multiplexers:** When CCTV security systems have multiple cameras, an electronic switcher, quad, or multiplexer is used to select different cameras automatically or manually to display the images on a single or multiple monitors, as individual or multiple scenes. The quad can digitally combine four cameras. The multiplexer can digitally combine 4,9,16, and even 32 separate cameras.
8. Housings fall under the categories of indoor, outdoor and integral camera/housing assemblies such as: Dome housing in which the camera uses a hemispherical clear or tinted plastic with pan-tilt-zoom lens capability. In addition, there is plug and play/housing combinations in which its surveillance camera are packaged in the camera-lens housing.
9. **Pan/Tilt mechanism:** The camera must view a large area span and tilt mount is used to rotate it horizontally (panning) and to tilt it thus. Providing a large angular coverage.
10. **Splitter/Combiner:** An optical or electronic image combiner or splitter is used to display more than one camera scene on a single monitor.
11. **Annotator:** Time and date generator annotates the video scene with chronological information. A camera identifier puts a camera number (or name) on the monitor screen to identify the scene displayed on the camera.

4. Findings

Video surveillance systems also known as Close Circuit Television (CCTV) is the systematic investigation or monitoring of the actions or communications of one or more persons in a place. Video surveillance has been a key component in ensuring security at various institutions due to the increase in crime rate ranging from armed robbery, kidnapping and recently bomb blasts around the globe which has necessitated its installation in most establishments.

This study therefore described the steps involved in designing an improved video surveillance system. The study discussed the theory of improved video surveillance types, components involved, selection of the best equipment and the details of its virtual design. The system was designed to monitor the footages of a particular surrounding with a camera resolution of 1680 by 1050 and the monitor displayed the desired output from a simulated implementation of the system with the router which served as an internet connection that transmitted the signal over the internet to any device with internet access.

An improved video surveillance system has therefore become a foremost global strategic tool for fighting the war against terrorism, preventing crime, protecting cooperate assets and enhancing public safety which has made forensic investigations very easier for the police force.

The crime rate (crime incidence per 100,000 of population) in India increased from 383.5 in 2018 and 385.5 in 2019 to 383.8 in 2020 according to the National Crime Records Bureau. The rise in crime in 2020 has been generally attributed to COVID-19 related restrictions and violations. 2020 saw a fall in crimes such as rape, kidnapping and crime against children, while disobeying public servant related crimes increased 21%.

**Table 1:** Shows in Total IPC & SLL Crimes (State/UT wise) 2016-2019 % Share of state/UT

State/UT	Total IPC & SLL Crimes (State/UT wise) 2016-2019		% Share of state/UT		
	2018	2019	2018	2019	Change
India	5074634	5156172	100	100	-

Table 2: Crime Rates

State/UT	Total IPC & SLL Crimes (STATE/UT wise) 2016-2019		Crime Rate (IPC& SLL)				
	2018	2019	2018	2019	Change	2020	Change
India	5074634	5156172	384	386	(-2)	488	(-102.3)

Data is based on the annual "Crime in India" publication by the National Crime Records Bureau.
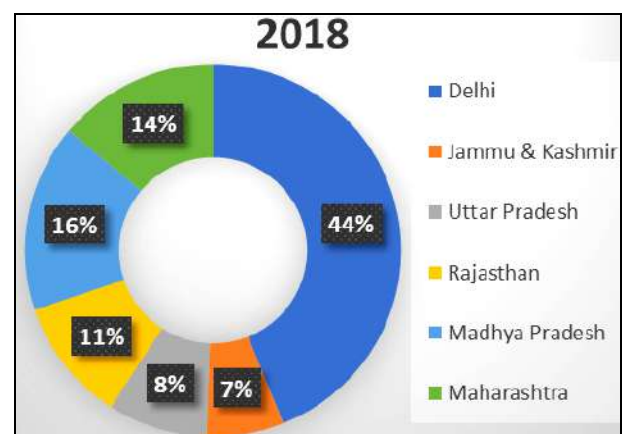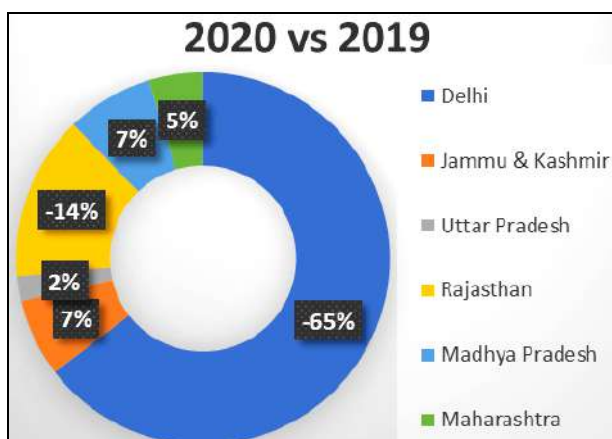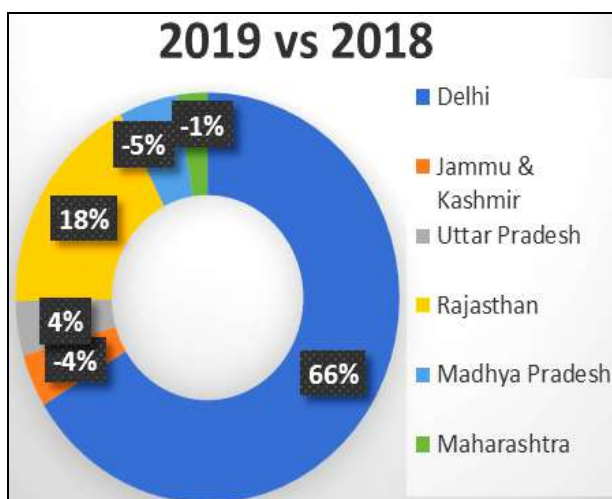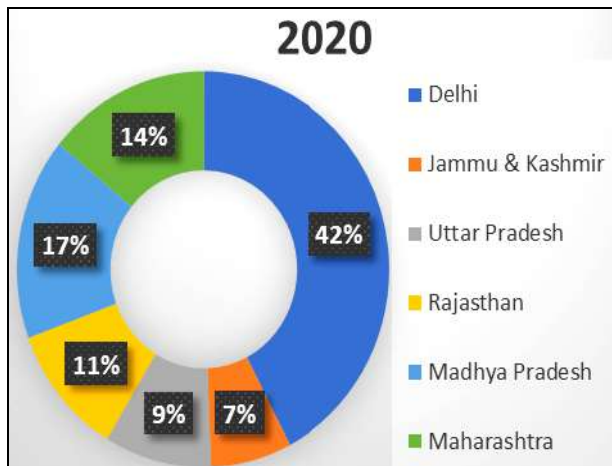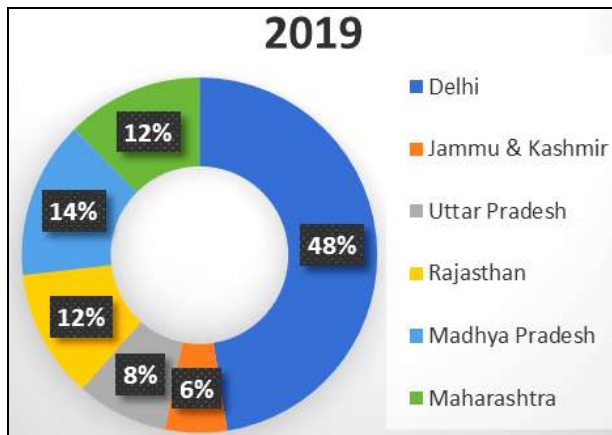
According to a recent study, Delhi has 1,826 CCTV cameras installed per square mile, putting it at advantage over metros such as London, Shanghai, Singapore, New York and Beijing. For a metropolitan city with a high crime rate, CCTV technology is today clearly an integral part of policing, investigation and crime control.

It's almost routine now, after a crime is reported, for the investigation officer to try get his hand on NVR or DVR of the CCTV cameras around the crime site. Almost all police station now have specialized CCTV analyser who are trained to find the possible suspect from the footage.

4.1 What Is a Network Video Recorder (NVR)?
The Network Video Recorder (NVR) receives, stores, and manages digital video streams transmitted by IP cameras over the network. The NVR allows you to watch, browse, play back, manage, and store multiple IP cameras at the same time. Freed from the constraints of computer hardware, no longer faced with the tedious installation of software. If all cameras are networked, a central management core must be required.

The NVR obtains encoded and compressed video streams from the network and then stores and forwards them. The letter N indicates network transmission. Therefore, we generally don't see a direct connection to the video signal on the NVR device. The input and output are IP data that has been encoded and added with network protocols.

A. Independence
The NVR needs to work with the IP camera or DVS to store and manage PU videos.

B. Physical Location
In actual application, NVR deployment is flexible and not restricted by physical locations. That is, NVRs are not restricted by physical locations of cameras, encoders, and control centers and only network connectivity is required. The NVR mainly considers the proper allocation and deployment of network video stream bandwidth.

C. Openness
The NVR adopts the open IP architecture and needs to work with the encoder, management platform, operating system, network transmission, and storage devices to implement complete functions. Therefore, the NVR has good integration capability and is more convenient and flexible. In addition, NVRs can run based on universal servers and operating systems, breaking the proprietary and closed pattern of devices in the security surveillance field.

D. Interface
NVRs are mainly used to store and forward videos. They are usually deployed in the second-level equipment room as middleware. This means that NVRs are far away from sites, interfaces and workstations. Therefore, deploying redundant interfaces for it means an increase in costs.
Network Video Recorders have replaced legacy Digital Video Recorders (DVR). Advantages include:
- Record video and audio.
- Better image quality.
- System flexibility.
- Better viewing coverage.
- Wired or wireless
- Required 1 cable for video, audio and power.

- Recognition of faces, license plate, etc. due to better image quality.

Benefits of Network Video Recording
- Resolution of Recordings Offer 1080P high-definition recording capabilities and incredible picture clarity.
- Camera Connections
  NVRs are readily more scalable than DVRs.
  NVRs are the most common way to store and access footage from IP cameras
- Hybrid Video Recorders can function with both analog cameras and IP cameras.

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