SURVEY: VIDEO FORENSIC TOOLS

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ABSTRACT

Due to extension of using CCTVs and the other video security systems in all areas, these sorts of devices have been introduced as the most important digital evidences to search and seizure crimes. Video forensics tools are developed as a part of digital forensics tools to analyze digital evidences and clear vague points of them for presenting in the courts Existing video forensics tools have been facilitated the investigation process by providing different features based on various video editing techniques. In this paper, some of the most popular video forensics tools are discussed and the strengths and shortages of them are compared and consequently, an alternative framework which includes the strengths of existing popular tools is introduced.

Keywords: *Forensic Tools; Video Forensic; Analysis Tools, CCTV*

1.   INTRODUCTION

Today, CCTV systems record every daily activities in almost all public zones; qua every misbehavior might be prosecutable by them greatly. In this way, analyzing the recorded videos needs to have exclusive technical tools which have been developed based on many complex algorithms. As other digital forensics tools, Video forensics tools have some common steps that define fundamental features of video analyzers which are listed as below:

- Reliably digitize video tape footage onto a computer system
- De-multiplex or separate camera views from multiplexed CCTV footage
- Convert digital video from DVR (Digital Video Recorder) devices into digital video formats usable for forensic analysis.
- Perform clarification techniques such as frame averaging
- Highlight someone or something of interest in t video
- portions of the video for areas of interest

Therefore, video forensics tools must convert images from various media on a centralized digital laboratory without any quality lost then analyze scenes that might be damaged or recorded in the bad situation such as low brightness environments. Many kinds of video forensic tools are developed by many companies as commercial or open source forensics tools which have their advantages and limitations. However, the rest of the paper organized as follow:

Section 1 introduces some of the most popular video forensics tools and discusses their operational features which will be compared to each other in section 2; then section 3 introduces an alternative overall framework to launched current limitations logically and section 4 presents a conclusion for this survey briefly.

2.   VIDEO FORENSICS TOOLS

In fact, several video forensics tools have been introduced by many companies, but some of them work as a part of an enterprise forensics tools or a graphical forensics tools but those tools

which are developed exclusive as video forensics tools are discussed in this section.

3. OCEAN SYSTEMS DTECTIVE

Ocean Systems dTective is a relatively complete forensic multimedia processing, analysis and presentation solution. It is composed of different modules and various features for capturing, analyzing and processing videos.

A. Capturing videos

For capturing digital surveillance, DVR dCoder is designed to aid investigators in the conversion of digital surveillance files from a proprietary format to standard formats for future processing. The digitized footage is a duplicate of the original file in an uncompressed digital format. DVR dCoder captures a copy of the original and exports it to an uncompressed open media format such as TIFF, QTIME or AVI. It supports cell phone 3GP video files and also allows users to either capture the entire DVR video or the selected region. Furthermore users have the option to view various statistics about the captured video.

B. Analyzing videos

For analyzing videos dTective uses de-multiplexing and de-interlacing techniques. For this purpose dPlex Pro as a part of dTective converts the multiplexed video into demultiplexed video, in order to ease the evaluation of video evidence It has the ability of de-multiplexing video recorded from any multiplexed video source and shows multiple camera views simultaneously. It makes possible to save any demultiplexed camera view as an individual video clip and arrange camera views by order of importance. Also it makes possible to save multiple de-multiplexed camera views in a matrix view of up to 16 cameras.

Many multiplexed devices record a single camera image on each field of video, but most playback machines only display the odd field hiding all of the video evidence contained in the even field. dTective separates each individual frame of video into two unique images, allowing the investigator to examine the evidence at the field level. Field-based examination frequently reveals images normally lost to the investigator.

C. Processing Videos

dTective uses different techniques implemented in different features for processing videos which are briefly described below:

dVeloper With dVeloper, it's easy to isolate the video color space that holds the most valuable information. By analyzing the entire video, or just a region of interest, dVeloper automatically adjusts brightness, contrast and gamma to bring out more detail. dVeloper removes noise and video graininess through a time-lapse processing technique called frame averaging.

SpotLight is a quick and easy to use dTective module that allows the analyst to select a region of video highlight or blur. User can define a shape anywhere from a square to a circle, then work with either the inside or outside of that shape using different filters, including blur, mosaic and scatter. All of these filters have a variable intensity setting. User can even apply a border color to the shape to focus more attention on your area of interest. All of the settings can be changed over time, allowing you to track a face or object as it moves as well as adjust user`s settings to accommodate for the object changing size as it gets closer or further away in the video.

arithMATIC can be especially useful in cases where user needs to determine what has changed from frame to frame. For example, arithmatic subtraction can be used to determine what may be missing from a burglary scene by comparing a video from before the burglary to a video after the burglary.

MAGNIFi enlarges a section of the video and displays the result either full screen, or to a user defined portion of the screen. The analyst can leave the enlarged image as is, or select a mathematical filter to further clarify the results. Magnifi provides independent controls of both target and output borders. These are especially useful when presenting the results in court.

Image Stabilization with Image Stabilization, an analyst simply draws a region of interest box around an unstable area of video and allows the computer to track and stabilize the video. user can choose to stabilize vertically, horizontally, or both. Stabilization can also be achieved manually, using a Picture-in-Picture effect and specifying key frames.

Color Correction Color correction is a powerful, real-time process that greatly expands the forensic capabilities of a detective system. The easy-to-use color correction tools analyze and correct poor lighting and compensate for camera dome filters to recover the accurate colors of the original scene. Grayscale correction overcomes inaccurate reproduction of dark or light pigment in a suspect's features - even when captured on black-and-white video.

Picture-in-Picture has the ability to display one moving image within another offers dynamic, side-by-side comparisons, demonstrating consistencies between known images and suspect images. Time and date stamps can also be moved to a magnified area of the video for accurate image reference during trial. Picture-in-Picture helps to reveal the truth behind the video.

Comparitive Analysis (Reverse Projection) Reverse Projection and reliable height analysis are made easy with the Avid superimpose feature. After isolating a suspect on video, an analyst can superimpose a calibrated measurement standard over the suspect's picture and then 'look through' one video track into another. This simple comparison clearly determines the suspect's actual height.

Title Tool can be used to help explain complicated video evidence and often assist the court in understanding the relationship between camera angles or video sequences. The title tool uses any standard windows system fonts, and includes draw objects such as circles and boxes.

4.   MOTION DSP

Ikena , MotionDSP's forensic video enhancement software for Windows, has been designed to accelerate video forensics using state-of-the-art, automated image processing that can can capture video from proprietary DVR video players and quickly extract forensically valid results from any video source. Based on innovative super-resolution-based reconstruction algorithms. Ikena also comes in a GPU-accelerated version, Ikena GPU, which can use graphic cards (GPUs) from AMD and NVIDIA to process video up to 5x faster than on CPU. Ikena has different features which are categorized below:

Super Resolution: MotionDSP has the ability to reconstruct video, increasing resolution and removing noise. The super-resolution reconstruction process involves analyzing a large number of video frames, determining what the best information is, and using that information to reconstruct each frame of video. MotionDSP sophisticated motion estimation algorithm reconstruction of scenes with "complex" motion i.e. videos with moving objects, camera shake, or even both.

Image Stabilization: Ikena's stabilization algorithms leverage MotionDSP's accurate multi-frame motion estimation. Because of the accuracy and robustness of its motion fileds, Ikena uses a buffer of 31 video frames (51 in Ikena ISR) to vastly reduce shake and produce the stabilization correcton.

Deblur & Deinterlace: Ikena uses a special deblurring filter (bilateral total variation) that is able sharpen images without the typical increase in noise seen with edge sharpening or unsharp mask. Ikena can DE interlace interlaced video, which could include MPEG2- encoded files from a DVD, or MPEG-encoded videos from security cameras. MotionDSP's deinterlacing uses super-resolution techniques to extract extra information from the two interlaced fields, treating each field as a separate frame, allowing Ikena to accurately

fuse those fields into a single progressive image, without artifacts.

Lighting & Contrast: Ikena has an advanced contrast algorithm that allows details to be "pulled" from dark videos, called "contrast-limited adaptive histogram equalization." This algorithm uses both automatic contrast adjustment, which combines exposure information from multiple frames of information. Ikena also has a standard set of tools for manual light and contrast adjustment, using shadows/highlights, gamma, color saturation, and color temperature.

Evidence spotlight tool: Using MotionDSP's proprietary object-tracking technology, Ikena Spotlight is able to track selected individuals and objects as they move around the scene.

5.   COGNITECH'S VIDEO INVESTIGATOR

Cognitech's Video Investigator® software is sold as part of Cognitech's Tri-Suite software package. The Video Investigator® software is designed to work with video files and still images alike. There are a variety of methods that can be used in either scenario, which is what makes Video Investigator a powerful tool for video forensics. It offers the vast array of filters that can be used by investigators. Listed below are a number of tools available in this software package.

File Conversion: This tool allows useer to convert files in a variety of ways, whether RGB to YUV, 8-bit to 16-bit,8-bit to 32 bit, etc.

Deblur Filters: These filters allow user to deblur single frame or movie clips. There are 5 deblur filters that work in different ways to deblur the image. The Sharpen and Weiner filters are classic techniques that work very quickly. While Movie Deblur and Total Variation are techniques that Cognitech developed, Movie Deblur, Motion Deblurring is a new technique developed by Cognitech that utilizes image registration to determine the motion of a video and deblur it based on that motion.

Demultiplexing: This filter allows user to demultiplex a video based on its visual content. This approach looks at the image directly and sorts it to the appropriate movie. It is a universal demultiplexer since it does not read the multiplexer encoding on the videotape.

Denoise Filters: It has six denoising filters which allow user to remove noise in single frames or movie clips. The Median and Average Frames technique are based on classic image processing techniques. Movie Denoise, Remove Extrema, Total Variation Denoise, and JPEG Deblocker are all based on techniques developed by Cognitech.

Detection Filters: Frame Difference allows user to view the intensity difference between two frames of a movie. Gradient is a visualization tool that allows user to view the different adjacent pixels.

Editing: The editing filters allow user to cut and concatenate videos. Concatenation allows user to combine two different movies.

Histogram Editor: The user can adjust the Red-Green-Blue (RGB) or Hue-Saturation-Intensity values in an image or movie.

Tracking: The Tracking and 3D Shape Matching techniques were developed by Cognitech and used to automatically track motion in a video.

Transform: These are filters that allow the user to perform different functions. Mirror Image allows the user to rotate or flip the image or video in different directions. Geometric is used to zoom/reflection, shear (deformation of a rectangle into a parallelogram), rotate and translate an image or movie. Wavelet is an advanced filter that demonstrates the 2Ddyadic wavelet transform for spline wavelets of minimal support on a rectangular domain. Fourier is another advanced transform filter that computes the 2D discrete Fourier transformation of an image.

Zoom: This filter allows the user to try six different techniques in order to rescale an image or a movie. This allows for a better rescaling effect, as typical methods tend to use a pixel duplication method to rescale an image, which quickly leads to a stair-like effect called pixilation.

Velocity: The Velocity filters are the centerpieces to Video Investigator and its Reconstruction methods. These filters allow the user to estimate the motion in a video clip either automatically or by manual methods. These filters have been developed by Cognitech and are the first step in performing a Reconstruction Technique. Correlation Matching, Line Segment Matching, Motion Segmentation, Phase Matching, Segmentation Shape Matching, and Shape Matching are all automatic registration methods and Manual Matching is a manual method that uses the glyphs feature in the Video Investigator software.

Reconstruction: These techniques use the velocity filters to perform different operations based on the motion estimated by the velocity filter. Frame Fusion allows the user to use the velocity of each frame and improve the quality of the movie. Mosaic Reconstruction uses the information to reconstruct the movie using information from several frames to improve velocity information to reconstruct a single frame image based on the common information in all of the frames. Stabilization Reconstruction allows the user to use the velocity information to stabilize the video footage and is very useful in visualizing what is going on in the movie.

Photogrammetry: Photogrammetry is a technique that allows the user to go back to a crime scene, take several measurements of the crime scene and estimate the height of a suspect or object in the scene.

6. TREC – VIDEO FORENSIC

Forensic video image analysis bridges the relationship between video image processing, law enforcement, industrial security and the courts.VCR tapes suffer noise, low light level environments, motion blur, and time base synchronization problems. Perpetrators are too small for identification and four camera scenes are compressed to a single frame, quad format. All these situations have been successfully resolved by forensic image processing techniques. Actual crime scene results highlighting one or more of the specific problems and the associated solution will be presented by the 35 mm slides, side by side for comparisons in TREC video analysis software.

However, according to the mentioned common principles between video forensics tools, the operational features of TREC can be introduces as follow:

- Real Time Color and Gray Scale Selectable Capturing
- Magnification X2 /optical quality
- De-Multiplexing: Analogue and Digital
- DeJitter, Deblur.
- Double Data Rate, 30 fps to 60 fps
- High Frequency Resolution Enhancement
- Sharpening, Contrast & Brightness Adjustments
- Input Formats: TIF, JPEG, AVI, BMP, RAW, MIM,VHS, RS170, CCIR, PAL
- Output Formats: TIF and AVI
- Format Conversions-Color to RGB-Y& Processing in Monochrome for highest resolution results
- Random selection of processing options
- Courtroom tried & tested, results satisfy

7. FOREVID

Forevid is one of the open-source software for the forensic analysis of surveillance videos. Forevid offers you an extensive set of features required in your forensic case work, including e.g. various options for video playback, processing and result documentation.

Actually Forevid is usable for different purposes. Either using as an intuitive and simple tool for previewing surveillance videos, or as an advanced tool for enhancing low quality videos, analyzing the events in videos and documenting

your analysis results. It is developed at the Forensic laboratory of National Bureau of Investigation, Finland. The software is freely available under the terms of GNU General Public License. In this way, operational features of Forediv divide as Playback, Video processing, documentation and others which are discussed in the rest of this section.

Playback: Forevid provides playback for videos stored with a variety of different containers and codec. When importing a new video user can select one of the following methods for importing as FFmpeg in which Video is imported using the built-in FFmpeg library, DirectShow in which video is imported using the Microsoft DirectShow framework, Video for Windows in which video stored in AVI format is imported using Microsoft's legacy Video for Windows framework; in order to successfully import the video, the file needs to be in AVI format, and operating system needs to have necessary VFW codec installed, and Avisynth script - AviSynth script file is imported as a video.

Video Processing (Filtering): The filters are divided into four categories, according to their function: *resize*, *enhance*, *deinterlace*, and *other*.

Resize is divided as following types:

- PointResize - The simplest resize possible. Resizing is done using the Nearest Neighbour algorithm, which usually results in a very blocky image.
- BlinearResize - Resizes the input video frames to an arbitrary new resolution using bilinear filtering.
- BicubicResize - Similar to BilinearResize, except that instead of a linear filtering function the Mitchell-Netravali two-part cubic function is used.
- Lanczos4Resize - Alternative to BicubicResize which produces quite strong sharpening. It usually offers better quality (fewer artifacts) and a sharp image.
- Spline36Resize - Spline based resizer using 6 sample points.

Enhance

- Sharpen - Sharpens the video frames. The parameter controls the amount of sharpening applied.
- Blur - Blur the video frames. The parameter controls the amount of blurring applied.
- Deblock - Deblock the video frames. Parameter *quant* controls the strenth of deblocking.
- Spatial Soften - Remove noise from video frames by selectively blending pixels.
- Temporal Soften - Works similarly as SpatialSoften, except the pixels are searched in nearby frames, instead of nearby pixels in the same frame.
- Levels - Adjust brightness, contrast, and gamma of the video. Parameters *low* and *high* determine what input pixel values are treated as pure black and pure white.
- Invert - Invert the colors of the video.

Deinterlace

- SeparateFields - Takes a frame-based clip and splits each frame into its component fields, producing a new clip with twice the frame rate and twice the frame count.
- ComplementParity - If the input clip is field-based, Complement Parity changes top fields to bottom fields and vice-versa.
- Bob - Takes a clip and bob-deinterlaces it. This means that it enlarges each field into its own frame by interpolating between the lines. The top fields are nudged up a little bit compared with the bottom fields, so the picture will not actually appear to bob up and down.

Other: This feature is consists of Flipping and Rotation to left and right.

Documentation: It is an essential part of every case. In Forevid, you can document your results by exporting still-images and re-encoded videos, or by generating bookmarks and PDF-reports.

- **Supported formats:** according to features provided into the software, supported formats for forediv are *MPEG-4*, MKV, MPEG-4 Part 14 (mp4) and Flash (flv). In addition, the encoded video can be exported wrapped inside a self extracting video player (SFX Player), which automatically plays the included video.

- **Other facilities:** these features can be describable as some miscellaneous features of Forevid. Such as editing video tools and hash value comparison tools which are some simple edition on the video such as cut or merging processes and comparison hash value of two video to ensure about their similarity respectively.

8.   KINESENSE

Kinesense LE is the portable solution for retrieving, searching and analysing evidence from large volumes of CCTV video. The manpower required to gather, convert and review the video footage is enormous. The ability of monitoring personnel to hold attention and to react to rarely occurring events is prone to error, due to lapses in human attention. Kinesense automates video retrieval and combines advanced video analysis technology with an intuitive user interface in a compact portable CCTV Analysis Kit [12].

Kinesense forensic divided to four parts such as: Kinesense LE, Video analyses kit, Kinesense covert Suite, and Kinesense report.

Kinesense LE: Kinesense LE gives investigators advanced video analytics technology in an easy to use application to accelerate investigations, reduce human effort and assure evidential integrity at every stage in the investigation. Kinesense LE enables investigators to analyze video evidence 20 times faster than before. It is ideal for retrieving and searching footage from 3rd party analogue and digital CCTV systems and for analysing video evidence from overt and covert surveillance operations.

The features of Kinesense LE are:
- Video Retrieval**:** Retrieve from analogue or digital CCTV systems. Quickly make evidential-grade copies of analogue or digital

footage. Convert proprietary incompatible video formats into viewable and searchable formats

- Search and analysis**:** Fast accurate search within video scenes. Search for people, vehicles, colour, direction of movement, and area of scene. Search results are colour-coded and displayed on video timeline for rapid review
- Evidence Preparation: Magnify, blur or highlight specific areas in scene. Quickly create comprehensive evidential-grade documents and video clips. Complete audit trail of all actions on system, with assured integrity against tampering

Video analyses kit: Kinesense Video Analysis Kit packs all of the power of Kinsense LE into a rugged portable package. It is ideal for retrieving and searching footage from 3rd party analogue or digital CCTV systems and for analyzing video evidence during overt and covert surveillance operations. When responding to major incidents, **every second counts**. Kinesense Portable Video Analysis Kit puts advanced video analytics technology at the scene in a rugged rapid-deployment unit [12].

The feature of Video analyses kit is:

- Tough kit**:** Full Kinesense LE pre-installed on tuned high spec laptop. Tough flight case, with manuals and quick-start guide. All of the cables and connectors to retrieve video from digital and analogue CCTV systems
- Rapid deployment**:** Retrieve all video at scene of incident without removing recording systems. Retrieve from any analogue or digital CCTV system. Brief the investigation team fast with photos, video clips, and incident timelines
- Assured integrity**:** Capture all the metadata necessity to assure evidential integrity. Complete audit trail, with assured integrity against tampering. Securely backup all evidence gathered and metadata

Kinesense covert Suite: Covert surveillance teams worldwide depend on Ovation Systems' AfterBurner™, the market leading time-lapse DVD recorder. Once surveillance video is recovered from surveillance sites, the human effort required to review the raw product is substantial.

The feature of Kinesense covert Suite is**:**

- Covert Autoloader™: Loads up to eight AfterBurner DVDs in a single unattended process. Reads timestamp information from AfterBurner DVDs automatically. Creates a single searchable video timeline.
- CovertSearch™: Create search filters for areas of interest across entire timeline. Presents search results on an easy viewable timeline for rapid review of events. Brief the investigation team fast with photos, video clips, and incident timelines.
- CovertSearch™: Annotate images or video clips. Blur, magnify and highlight areas of frame. Export evidential-grade reports to DVD, PDF and Microsoft Word formats.

Kinesense Report: Kinesense Report is the easy to use tool for video evidence creation. Stitch clips from different cameras to map out a suspect's movement. Within minutes, create a report highlighting the suspect's movements from entry to the building to leaving the scene of the crime. And the feature is:

- Video Report**:** Fast report creation. Batch video file import. Spotlight and blur annotation. Export to DVD & AVI format. Evidence reporting. Chain of evidence report

Videntifier Forensic (Automatic Video Identification):

Videntifier™ Forensic provides police authorities with an automatic and easy-to-use video identification system. A single mouse click is sufficient to automatically scan an entire hard drive for suspicious and illegal video material. With its speed, Videntifier™ Forensic saves investigators precious time, which they can spend on other more challenging tasks, rather than inspecting thousands of video files manually. At the end of each scan Videntifier™ Forensic returns a summary report, listing which videos have been identified [11].

Videntifier Forensic has four services such as gold, silver, basic, and platinum. That each service make good situation to usage work with this tools better than other. The benefits of Videntifier™ Forensic are: robustness, security, central database. Robustness: Many points per image are taken into account, so Videntifier™ Forensic is also very robust against cropping and clipping of the video content. Furthermore, rotated and mirrored versions are easily identified. Security: Videntifier Technologies has taken several measures to make the Videntifier™ Forensic service very secure. First of all no image data is sent over the internet or reaches the Videntifier™ Forensic server. Only fingerprints are sent as a query or insertion request to the NV-Tree database server, and only over a secure, isolated connection. Central database: The central database holds the fingerprints of all video material. During the identification process the fingerprints of each video frame are queried against the database. In case several frames are recognized the videos name, classification and description is sent back to the client [11].

The features for Videntifier Forensic are:

- Search speed

- Accuracy

- Insertion supported

9. FEATURE COMPARISON

In this section all the features of the above mentioned softwares have been compared in a table based on their strength in facilitating the investigation process by using various video editing techniques. The table illustrates which software has the mentioned features and how perfect it is according to its functionality, variety of services it provides and also the technology behind the features. Each of the software features is assigned a level of strength which is shown by number of signs in the relative row and column according to the features description in the previous section. Below is the comparison table:

10.   PROPOSED FRAMEWORK

According to comparison between categorized features of the discussed video forensic tools, it seems possible to propose an alternative framework which combines strengths of each tool and solve their limitations. In this way, according to the study, main principles of video forensics tools can be introduced as three main conceptual phases as Video Capture,

Video Analysis, and Video Processing in which video evidences convert from digital or analogue media on a reliable centralized storage, images demultiplex from multiplexed cameras and prepare for processing, and images are processed and their problems solve by using various algorithms respectively; Figure 1 shows main conceptual phases of each Video forensic tool.

Actually, proposed framework should combine strengths of discussed forensics tools to provide an stronger equipment. In this way, operational features of the proposed framework are listed as below:

Convert digital video from DVR in which various supporting formats and codec are very essential in the system, so proposed framework should handle many sorts of video formats such as AVI, MKV, 3GP, WMV, MPEG4 and also capturing videos directly from DVR systems. Therefore, the proposed alternative framework uses features of Ocean Systems dTective for this operation, and also according to the comparison table it is clear that some other important operation techniques such as De-multiplexing and Object-Tracking is coming from Ocean Systems dTective too. Actually, the proposed framework uses De-noising methods of

Kinesensewhich has introduced perfect features in related and also frame comparing technicus of Kinesense is used in the proposed framework too; motion blurring, color correction, and enlargement is coming from Cognitech's Video Investigator and Forediv forensic tool because they use very strong methods in related to mentioned features as elaborated before.

Video Analysis, and Video Processing in which video evidences convert from digital or analogue media on a reliable centralized storage, images demultiplex from multiplexed cameras and prepare for processing, and images are processed and their problems solve by using various algorithms respectively; Figure 1 shows main conceptual phases of each Video forensic tool.

 Another essential feature in the proposed framework is video stabilization that its operations and techniques is coming corresponding to MotionDSP Ikena which uses qualified techniques about it.

Consequently, according to compared features, the proposed framework combines the most strength operational features from discussed tools to improve their advantages and remove their specific limitations. Therefore, designed framework can be introduced as a faster system with better accuracy in comparison with the mentioned video forensics tools and it can captures, analyses and processes video evidences dynamically.

11.   CONCLUSION

Regarding our study on existing video forensics tools and comparing the common features in the most popular software's and their strengths and weaknesses, we think that a unified model which benefits from the strength points of existing tools and accordingly improve the usability of the software by providing a complete range of features may be a good alternative framework. Although integrating various strong features in a software will makes the investigation process easier and more precise, still there would be a need for further research to propose enhanced video editing techniques to speed up the video editing process which will have grate impact on improving video forensics tools.

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