Advanced Signal Processing Method for The Video Detection and Monitoring of TV Datacenter

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Abstract: A TV Datacenter is a structure that houses computer systems and other components such as telecommunications and storage systems. Broadcast automation is the technique of using broadcast programming technology to automate broadcasting procedures. Available software comes at a hefty price and isn't well-suited to dealing with visual problems that might occur during TV broadcasting. As a result, detecting and correcting broadcast faults becomes essential. The primary goal of this research is to provide a comprehensive and innovative method for accommodating Datacenter expansion, improving data transmission in Datacenters, and detecting mistakes and issues in TV Datacenters. The system provides a technically simplified solution for resolving video-related issues during TV transmission. This has been accomplished through the use of rather advanced video, and signal processing techniques, as well as the introduction of machine learning algorithms for the automatic identification and rectification of video errors that may arise when videos are being broadcast on television. In this study, two forms of video defects have been considered: videos that halt and become black, and films that freeze. The results obtained using the algorithms showed a detection rate obtained of 83.33% which can be considered to be an indicator of the high performance of the proposed detection system. Moreover, according to the results, the minimum time of replacement is zero seconds meaning that the replacement was done automatically after the detection of the corruption in the video. The results also showed that for all videos, the detected number of frames were all successfully replaced. The frame replacement showed 100% efficiency for every video.

Keywords: TV Datacenter, Monitoring, Detection, Signal Processing, Video Frames, Detection Rate, Video Replacement

Received: June 7, 2021. Revised: March 9, 2022. Accepted: April 13, 2022. Published: June 29, 2022.

1. Introduction

A TV Datacenter or Datacenter also called a server farm is a facility used to house computer systems and associated components, such as telecommunications and storage systems. It generally includes redundant or backup power supplies, redundant data connections, environmental controls (e.g., air conditioning, fire suppression), and security devices. A Datacenter may be complex (dedicated building) or simple (an area or room that houses only a few servers). Additionally, a Datacenter may be private or shared. Datacenter components often make up the core of an organization's information system (IS). Thus, these critical Datacenter facilities usually require a significant investment of supporting systems, including air conditioning/climate control systems, fire suppression/smoke detection, secure entry, and identification and raised floors for easy cabling and water damage prevention.

The significance of the study relies on the algorithms that are proposed since these algorithms are completely novel as well as they are highly performant. In addition, these algorithms incorporate new technologies of video monitoring g and processing. Also, these algorithms are on new techniques such as feature extraction and the implementation of artificial intelligence.

Therefore, the goal of this work is to provide a technically advanced solution for solving errors that occur with videos during TV broadcasts. This is done through the implementation of relatively complex algorithms based on image processing along with the introduction of machine learning algorithms for the automatic detection and correction of video faults that can occur while videos are being streamed on TV. Two types of video errors are considered in this study: the first includes videos that stop and become black and the second includes freezing videos.

2. Literature Review

We list and discuss the work done in the most important studies related to Datacenter development.

Design and implementation of broadcasting and television program monitoring systems were proposed in (Qi & Chai, 2014). This research suggested a monitoring system called the broadcasting and television program monitoring system (BTP-MS), which is utilized to improve program monitoring on an autonomous, intelligent, and network-level and also to ensure broadcasting safety. The authors created a four-layer BTP-MS architecture consisting of a data collection layer, transmission, and storage layer, dispatching and configuration layer, and data analysis layer to fulfill the goal of improving system monitoring capability. The BTP-MS paradigm was devised and implemented in both hardware and software. The BTP-MS model was created and implemented the model in both hardware and software. The study showed that BTP-MS offers the ability to monitor, gather, and analyze data in real-time. Concerning automatic, intelligent, and network levels, this system increased the efficiency and stability of program monitoring at the automatic, intelligent, and network levels. The findings showed that the proposed methodology may significantly increase the efficiency and consistency of program monitoring to assure broadcasting safety.

Therefore, the proposed architecture was based on the Microsoft Azure Cloud Platform, which is a growing collection of integrated cloud services that allows to building managing of software and hardware through a Virtual Datacenter. In this architecture, the authors used Software as a Service (SaaS) and Infrastructure as a Service (IaaS) based on private cloud to provide high secure Computing Infrastructure, Servers, and mass storage. The authors showed that the proposed system provided several key benefits and allowed public authorities to reach a larger audience through radio and television. The proposed system also provided compatibility, allowing media content to be accessed at any time and from any location via multiple platforms and smart devices.

Tv program recommendation for groups based on multidimensional TV-anytime classifications was proposed in (Sotelo, Blanco-Fernandez, Lopez-Nores, Gil-Solla, & Pazos-Arias, 2009). The authors state that the introduction of digital television and personal digital recorders promises to alter how people watch television. The increased efficiency of digital coding will increase the number of materials available to users, necessitating the usage of automatic content recommendation algorithms. Digital recorders, on the other hand, will allow for a non-linear consumption model, allowing for the creation of (automated) tailored schedules that mix the most enticing materials for a particular user or group of users. So in this research, a method for predicting a group's interest in audiovisual content is proposed, which allows providing correct recommendations for the group. It formed homogenous and heterogeneous groups and explored various algorithms for each type of group, which reflects actual TV viewing behaviors. TV-Anytime metadata is widely used to provide the availability of precise enough content descriptions, and the viability of compatible mechanisms to annotate and gather users' profiles as a need for the development of interoperable consumer electronic devices. Furthermore, the personalization strategy takes advantage of synergies between multidimensional content categorization based on TV-Anytime metadata schemes and semantic reasoning techniques based on a domain ontology built from these classifications.

Many enterprises rely on IT Ticketing Systems to deliver fast, reliable internal customer service, resulting in improved IT department operations and satisfied employees (Coronel & Morris, 2016). Thus, in this paper, the authors describe the process of creating an IT Ticketing System from scratch for the IT Sector of a well-known organization in Albania - Albanian Radio Television, the public broadcaster of the country. The new way of collecting information about IT problems in the institution and also a new way of distributing work to the IT Staff members brought different benefits not only to the IT Sector in the television department but also to the employees which this sector supports. The system proposed and implemented was developed using JavaFX (Mohan & PremKumar, 2010) a software platform for creating and delivering desktop applications, as well as rich internet applications from Oracle.

Another TV monitoring is indicated in (Oliveira, Crivellaro, & Cesar Jr, 2005). This paper describes IBOPE Media’s scalable real-time audio fingerprinting system for radio and television broadcast monitoring. The Short-Time Fourier Transform was used to create a unique temporal feature extraction approach. When the system was given an input stream to analyze, it compares it to the database and automatically recognizes samples that have already been registered within the input stream. To find patterns and provide the final classification, the algorithm uses the temporal evolution of the signal frequency spectrum. To provide an effective and scalable search approach, the database in this study was clustered. A database of 393 different ads was used to evaluate the system. In less than three hours, a 41-hour audio feed from three separate TV stations was analyzed, yielding a 95.4 percent recognition rate.

Moreover, nowadays Artificial Intelligence (AI) is starting to be considered as a solution for Datacenter management and monitoring. Artificial intelligence already has a big impact on a lot of different segments in the media industry. With the broadcast industry moving to all-IP and Datacenter deployments those environments are more agile and complex than ever before. Traditional network management systems (NMS) and their paradigms no longer fit the bill, with rapidly evolving technologies and cycles, ever more mission-important systems, and continually changing operational techniques and DevOps style operations. Therefore machine-learning algorithms must find their way into network monitoring and management solutions to orchestrate a modern media Datacenter dynamically and proactively. A good big data storage architecture is the cornerstone for an AI-driven NMS platform; a lack of profound data and data hygiene is frequently one of the largest hurdles to successfully deploying big data initiatives. Because nothing remains static in today's all-IP environments, an AI creature must be extremely sophisticated. Unsupervised learning is essential for adapting to changing situations automatically. To successfully execute the correct management strategy, enhanced operation, and a zero-configuration, the zero-maintenance approach will be critical (Akbar & Azhar, 2018), (Gunkel & Vandenberghe, 2018), (Pryce, Yelick, Zhang, & Fields, 2018), and (Zhao & Ding, 2016).

Lately, the Internet of Things (IoT) has also been employed for the management of television big data processing. The study (Tong & Sun, 2021) recently conducted (April 2021) focused on the role of film and television big data in real-time image detection and processing in the Internet of Things era.

As stated in the study, images are becoming an increasingly essential data source in the Internet of Things, because of the rapid development of the Internet (IoT) (Want, Schilit, & Jenson, 2015), (Saha, Mandal, & Sinha, 2017), (Mishra, Ashu, & others, 2018), (Huanlai & Imran, 2021). The existing issues in image processing are evaluated from the standpoint of real-time image processing in this study to satisfy the low-latency and high-efficiency transmission method of the IoT platform. The backpropagation neural network (BPNN) was used to extract image features, and support vector machines were used to classify the images (SVM). The Adaboost framework based on IoT was used to build a real-time image detection and processing platform (RT-IDPP), and real-time image transmission and processing were realized using various databases. The proposed RT-IDPP for IoT was found to be capable of image detection and tracking. The suggested method can not only be used on a variety of cloud platforms, but it can also meet real-time needs in the picture detection and tracking process, ensuring that the image detection rate was greater than 97 percent. As a result, the detecting effect was improved. The proposed method has a greater detection rate and a lower false-negative rate (FNR) and false-positive rate (FPR) than standard image detection methods (FPR). The film and television big data (FTBD) database have a considerably stronger experimental detection effect than other databases

3. Study Design and Methodology

The methodology adopted involves the following basic steps (implemented in Matlab (Mathworks, Natick, MA, USA, 2019)):

- Input of a corrupted or a freezing video
- Detection of the corrupted/freezing part of the video
- Direct replacement of the corrupted/freezing part of the video

The algorithms involve both processing of video frames (image processing) and signal to process.

In the signal processing phase, the algorithm is trained to search in the extracted frames for the intensity and time values of the first instant at which the corrupted/freezing video occurs through detecting standard deviation for each image frame in the successive video frame images. At the point where the video is corrupted/freezing, the standard deviation of the image changes drastically to a zero/maximum value. Thus, the time at which the video is corrupted/freezing is detected. Then a corrective step is introduced where the corrupted/freezing video is replaced by another new video (could be an ad video) to compensate for the viewer.

The signal processing method can be scripted as follows (refer to **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**1)

As with the previous method, first, a video is input and the properties are extracted and displayed. Then the video is divided into frames and each frame is extracted separately where each video frame can be treated as a single independent image.

Next for each image, the intensities of all pixels are calculated in a manner to obtain a value that can differentiate between the different images that are extracted. After each image’s intensities are obtained, a standard deviation of the intensities is calculated. This step allows us to obtain one value (standard deviation) that is unique for each image. Thus, each image is characterized by one standard deviation value representing all its pixel intensities.

In addition to the standard deviation values, the time interval of each image extracted from the separate video frames is also calculated. In other words, the time interval of each video frame is obtained. So, each separate image now can be represented by two values; a standard deviation and a time interval.

As the standard deviations and time values are calculated for all images, so is the case for the images representing the video frame where the video is corrupted/freezing. The next objective is to determine the particular standard deviations and time intervals relative to the corrupted/freezing videos. For this sake, a search algorithm is initiated. The algorithm tracks the intensity differences between every neighboring image.

Knowing that the corrupted video (video that stops and becomes black) is characterized by intensities that have a zero-standard deviation (the video stops playing when it corrupts), the search algorithm is established to track the difference between images and detect where the standard deviation values are zero. As for the freezing video, it is characterized by intensities that have a constant standard deviation over a certain period.

Thus, the search algorithm is established to track the difference between images and detect where the standard deviation values become constant and continue to be constant.

When the zero/constant standard deviation value is detected for the corrupted video, this signals the beginning of the corrupted/freezing part of the video. The time value is also detected relative to the zero/constant standard deviation value.

At this point the search algorithm continually searches for the standard deviation values image by image, making sure that the values are still zero for the corrupted video and maximum for the freezing video indicating that the video is still corrupted/freezing. Accordingly, all time values are detected creating a certain time interval for the corrupted/freezing part of the video. The search algorithm goes on until the last zero value or the last constant value is detected. Thus from the start point till the endpoint of the corrupted/freezing video, a vector of zero/constant standard deviation values is recorded and a time interval is constructed.

The time interval for the zero o the constant standard deviation detected values across the corrupted/freezing video part is then extracted. For this time interval, where the video is corrupted/freezing, a corrective step is introduced.

The corrective step involves introducing a new video that is limited to the time interval detected when the original video is corrupted/freezing.

The video replacement can take place in a few milliseconds after the search algorithm detects the first few zeros or the first few constant standard deviation values. Finally, at the end of the time interval of the corrupted/freezing video, the new video is stopped and the original video is played again.

Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε. represents a demonstration of the method. The y-axis in the figure represents the standard deviation values for each image obtained from the separate video frame intensities while the x-axis represented the time values detected for every standard deviation image value.

The signal represents a video that is corrupted after around 6.5 seconds. As can be seen through the figure, the value of the standard deviation suddenly drops to zero at around 6.5 seconds representing zero intensities detected from the video. This is because, as noted previously, the corrupted part of the video has zero intensities and thus a zero-standard deviation for these intensities.

The signal in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**represents a video that is frozen after around 6.5 seconds. As can be seen through the figure, the value of the standard deviation suddenly shifts to a certain value at around 6.5 seconds and continues to be constant representing constant intensities detected from the freezing video. This is because, as noted previously, the freezing part of the video has similar intensities and thus a constant standard deviation for these intensities.

The video is corrupted/freezing from around 6.5 seconds to 12 seconds. During this interval, all standard deviation values are zeros/constant. This time interval is extracted and the corrupted/freezing video is automatically replaced by a new video with a delay of a few milliseconds. The new video continues playing as long as the standard deviation values are zero or constant as detected by the search algorithm

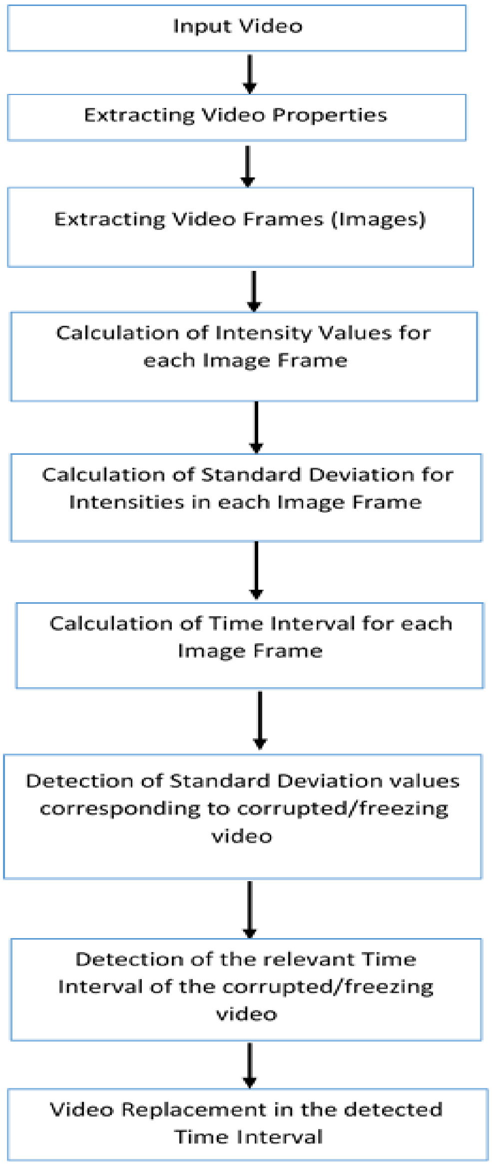

Figure 1 : Block Diagram for the Signal Processing Method

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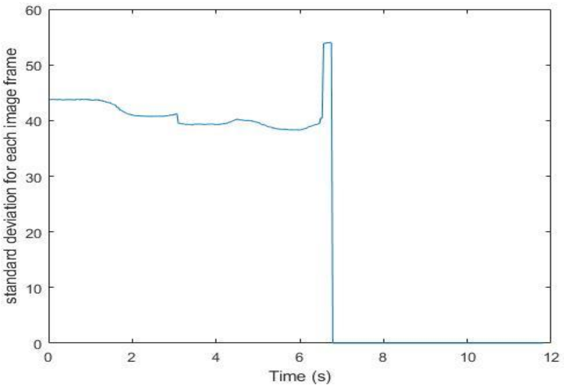

Figure 2: Standard deviation vs Time for each image (video frames) in the corrupted video

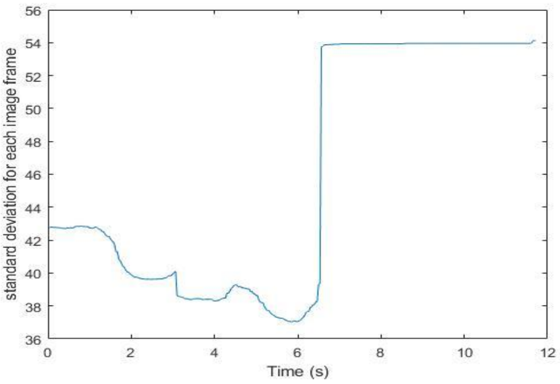

Figure 3: Standard deviation vs Time for each image (video frames) in the freezing video

4. Results

Before presenting the results of the detection and replacement phase we represent the properties of the videos that were used, including the number of frames, duration, and time of corruption (the time at which the video was corrupted).

As indicated in Table 1, a total of 12 videos was tested and 10 videos were successfully detected and replaced. The total number of frames tested was 10,138 frames with an average number of frames of 1014 frames. Video 1 has the lowest number of frames (353) and Video 4 the maximum number of frames (1784).

Table 1: Properties of videos used in the study

Video	Number of Frames	Duration	Time of Corruption
Video 1	353	25 sec	20 sec
Video 2	771	10 sec	6 sec
Video 3	862	28 sec	24 sec
Video 4	1784	59 sec	55 sec
Video 5	442	15 sec	10 sec
Video 6	1498	50 sec	44 sec
Video 7	1166	21 sec	17 sec
Video 8	676	22 sec	16 sec
Video 9	1505	32 sec	27 sec
Video 10	1081	36 sec	31 sec

4.1 Detection Rate

We evaluated the performance of the proposed system by calculating the Detection Rate (DR).

The Detection Rate refers to the percentage of the tested corrupted videos that were successfully detected and replaced out of the total number of videos tested.

The Detection Rate is calculated as follows:

$$\text{Detection rate} = \frac{Number\ of\ Sucessful\ Video\ Detections}{Total\ Number\ of\ Detections}$$

$$\text{Detection rate} = \frac{10}{12} \times 100 = 83.33\%$$

The detection rate obtained of 83.33% can be considered to be an indicator of the high performance of the proposed detection system.

5. Discussion and Conclusion

5.1 Discussion

For obtaining the above results, the methodology adopted involves the following basic steps:

- input of a corrupted or a freezing video;
- detection of the corrupted/freezing part of the video;
- and direct replacement of the corrupted/freezing part of the video.

The algorithms implemented involve both processing of video frames (image processing) and signal processing.

In the signal processing phase also, the video is divided into frames and each frame is extracted separately where each video frame can be treated as a single independent image. The algorithm is set to look for the intensity and time values at the initial moment at which the corrupted/freezing video appears in the recovered frames by identifying standard deviation for each image frame in the subsequent video frame pictures. The standard deviation of the picture varies dramatically to a zero/maximum value when the video is corrupted/freezing. The search algorithm is set up to track the difference between images and detect where the standard deviation values are zero, knowing that the corrupted video (video that stops and turns black) is characterized

by intensities with a zero-standard deviation (the video stops playing when it corrupts). The freezing video is defined by intensities that have a consistent standard deviation throughout a set length of time. As a result, the search algorithm is set up to watch the differences between photos and determine when the standard deviation values reach constant and stay constant.

At this stage, the search algorithm continues to look for standard deviation values image by image, ensuring that the values remain zero for corrupted video and maximum for frozen video, showing that the video is still corrupted/freezing. As a result, all time values are identified, resulting in a specific time interval for the corrupted/frozen movie. The search method continues until the final zero or constant value is discovered. Thus, a vector of zero/constant standard deviation values is recorded from the beginning to the conclusion of the corrupted/freezing video, and a time interval is formed.

Then, when the zero/constant standard deviation value is detected for the corrupted video, this signals the beginning of the corrupted/freezing part of the video. The time value is also detected relative to the zero/constant standard deviation value. Then, to compensate for the viewer, a corrective step is provided, in which the corrupted/freezing video is replaced by another fresh video (maybe an ad video). The corrupted or frozen video is replaced directly in a very small delay of a few milliseconds in both video/image and signal processing techniques created, and the algorithms established may be launched concurrently with the TV program being played. The video replacement can take place in a few milliseconds after the search algorithm detects the first few zeros or the first few constant standard deviation values. Finally, at the end of the time interval of the corrupted/freezing video, the new video is stopped and the original video is played again.

The results obtained using the algorithms showed a detection rate obtained of 83.33% which can be considered to be an indicator of the high performance of the proposed detection system.

5.2 Conclusion

A TV Datacenter is a structure that houses computer systems and other components such as telecommunications and storage systems. It usually consists of redundant or backup power supply, redundant data links, environmental controls (such as air conditioning and fire suppression), and security equipment. Today's TV Datacenters rely on networks that communicate using the IP protocol suite. TV Datacenters use routers, firewalls, and switches to route traffic between servers and the outside world. When two or more upstream service providers are employed to deliver a service, it is quite common. E-mail servers, proxy servers, and DNS servers are among the servers in the TV Datacenter that provide basic Internet and intranet services to the organization's internal users.

Building on this, the primary goal of this research was to provide a comprehensive and innovative method for accommodating Datacenter expansion, improving data transmission in Datacenters, and detecting mistakes and issues in TV Datacenters. Furthermore, the system was designed to monitor TV Datacenters in a sophisticated and reliable manner. The study's relevance was based on the presented algorithms, which are both wholly innovative and extremely performant. Furthermore, these algorithms included new video monitoring and processing technologies. These algorithms also rely on cutting-edge approaches like feature extraction and artificial intelligence implementation.

A playout software is essential for individuals working in television broadcasting operations. Due to growing storage space for hard drives, playout automation software applications are becoming more relevant in the television industry.

These programs play the source media and then distribute it in a way that the audience may consume it. A playout program might be as simple as a CD/DVD player or as complex as pricey television broadcasting software.

There are a variety of playout software options available, each with its own set of advantages and capabilities. This software, however, comes at a high cost and isn't well-suited to dealing with visual issues that may arise during TV transmission. As a result, detecting and resolving broadcast errors becomes increasingly important.

As a consequence, we developed a technically simple solution for overcoming video-related challenges during television broadcast in this project. This was done through the application of modern video and signal processing techniques, as well as the employment of machine learning algorithms for the automatic detection and correction of video defects that may occur during television broadcasts. Two types of video faults were studied in this study: movies that pause and become black, and films that freeze.

Matlab (Mathworks, Natick, MA, USA, 2019) techniques have been presented for implementation. The main objective has been to create an autonomous system that tracks and recognizes flaws and defects in currently playing movies, and then replaces the films in a later step with a very small delay or even soon after the error is discovered. The goal was to create a set of algorithmic manipulations based on image, video, and signal processing that are adaptable to different video inputs and can recognize films that stop playing and the screen goes black, as well as videos that freeze and become corrupted.

Based on this achievement, a novel approach for visual fault/error identification and correction is proposed. This system is based on a high-performing approach for automatically detecting various defects in any input video and precisely and automatically replacing the corrupted video or video segment.

As a result of its high detection rate and short replacement delay, the automation system described in this study can effectively replace other playout automation systems. As a result, the technology can improve TV broadcasting and provide a fresh viewpoint on how to cope with broadcasting flaws. Future work should aim for improving the proposed techniques by adding more feature (probably based on Artificial Intelligence) in order to achieve higher fault detection rates and decrease the video detection and replacement time.

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