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Content Protection System Using Matching Object for Cloud Based Multimedia.

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Abstract— We propose a new idea for large-scale multimedia content protection systems. Our design leverages cloud infrastructures to provide cost efficiency, rapid deployment, scalability, and elasticity to accommodate varying workloads. The proposed system can be used to protect different multimedia content types, including 2-D videos, 3-D videos, images, audio clips, songs, and music clips. The system can be deployed on private and/or public clouds. Our system has two novel components: (i) method to create signatures of 3-D videos, and (ii) distributed matching engine for multimedia objects. The signature method creates robust and representative signatures of 3-D videos that capture the depth signals in these videos and it is computationallyefficient to compute and compare as well as it requires small storage. The distributed matching engine achieves high scalability and it is designed to support different multimedia objects. Weimplemented the proposed system and deployed it on two clouds:Amazon cloud and our private cloud. Our experiments with more than 11,000 3-D videos and 1 million images show the highaccuracy and scalability of the proposed system. In addition, we compared our system to the protection system used by YouTube and our results show that the YouTube protection system fails to detect most copies of 3-D videos, while our system detects more than 98% of them. This comparison shows the need for the proposed 3-D signature method, since the state-of-the-art commercial system was not able to handle 3-D videos.

Key Words :3-D video, cloud applications, depth signatures, video copy detection, video fingerprinting.

I. INTRODUCTION

Advances in processing and recording equipment ofmultimedia content as well as the availability of free online hosting sites have made it relatively easy to duplicate copyrighted materials such as videos, images, and music clips. Illegally redistributing multimedia content over the Internet can result in significant loss of revenues for content creators.Finding illegally-made copies over the Internet is a complex and computationally expensive operation, because of the sheer volume of the available multimedia content over the Internet and the complexity of comparing content to identify copies.We present a novel system for multimedia content protection on cloud infrastructures. The system can be used to protect various multimedia content types, including regular 2-D videos, new 3-D videos, images, audio clips, songs, and music clips. The system can run on private clouds, public clouds, or any combination of public-private clouds. Our design achieves rapiddeployment of content protection systems, because it is based on cloud infrastructures that can quickly provide computing hardware and software resources. The design is cost effective because it uses the computing resources on demand. The design can be scaled up and down to support varying amounts of multimedia content being protected. The proposed system is fairly complex with multiple components,including: (i) crawler to download thousands of multimedia objects from online hosting sites, (ii) signature method to create representative fingerprints from multimedia objects, and (iii) distributed matching engine to store signatures of original objects and match them against query objects. We propose novel methods for the second and third components, and we utilize off-the-shelf tools for the crawler. We have developed a complete running system of all components and tested it with more than 11,000 3-D videos and 1 million images. We deployed parts of the system on the Amazon cloud with varying number of machines (from eight to 128), and the other parts of the system were deployed on our private cloud. This deployment model was used to show the flexibility of our system, which enables it to efficiently utilize varying computing resources and minimize the cost, since cloud providers offer different pricing modelsfor computing and network resources. Through extensive experiments with real deployment, we show the high accuracy (in terms of precision and recall) as well as the scalability and elasticity of the proposed system.The contributions of this paper are as follows. • Complete multi-cloud system for multimedia content protection. The system supports different types of multimedia content and can effectively utilize varying computing resources. • Novel method for creating signatures for 3-D videos. This method creates signatures that capture the depth in stereo content without computing the depth signal itself, which is a computationally expensive process. • New design for a distributed matching engine for high-dimensionalmultimedia objects. This design provides the primitive function of finding -nearest neighbors forlarge-scale datasets. The design also offers an auxiliary function for further processing of the neighbors. This two-level design enables the proposed system to easily support different types of multimedia content. For example,in finding video copies, the temporal aspects need to be considered in addition to matching individual frames. This is unlike finding image copies. Our design of the matching engine employs the MapReduce programming model. • Rigorous evaluation study

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using real implementation toassess the performance of the proposed system and compare it against the closest works in academia and industry. Specifically, we evaluate the entire end-to-end system with 11,000 3-D videos downloaded from YouTube. Our results show that a high precision, close to 100%, with a recall of more than 80% can be achieved even if the videos are subjected to various transformations such as blurring, cropping, and text insertion. In addition, we compare our system versus the Content ID system used by YouTube to

protect videos. Our results show that although the Content ID system provides robust detection of 2-D video copies, it fails to detect copies of 3-D videos when videos are subjected to even simple transformations such as re-encoding and resolution change. Our system, on the other hand, candetect almost all copies of 3-D videos even if they are subjected to complex transformations such as synthesizing new virtual views and converting videos to anaglyph and 2-D-plus-depth formats. Furthermore, we isolate and evaluate individual components of our system. The evaluation of the new 3-D signature method shows that it can achieve more than 95% precision and recall for stereoscopic content subjected to 15 different video transformations; several of them are specific to 3-D videos such asview synthesis. The evaluation of the distributed matching engine was done on the Amazon cloud with up to 128 machines. The engine was used to manage up to 160 million data points, each with 128 dimensions, extracted from over 1 million images. The results show that our design of the matching engine is elastic and scalable. They also show that our system outperforms the closest object matching system in the literature, called RankReduce [21], by a wide margin in accuracy and it is more efficient in terms of space and computation. The rest of this paper is organized as follows. We summarize the related works in Section II. In Section III, we present the design goals and a high-level description of the proposed system. In Section IV, we present the details of the proposed signature creation method. In Section V, we describe the design of the matching engine. Our implementation and rigorous evaluationof the whole system as well as its individual components are presented in Section VI. We conclude the paper in Section VII.

II. DISTRIBUTED INDEX FOR MATCHING MULTIMEDIA OBJECTS

A. Description:

This thesis presents the design and evaluation of DIMO, a distributed system for matching multimedia objects. DIMO provides multimedia applications with the function of finding the nearest neighbors on large-scale datasets. It also allows multimedia applications to define application specific functions to further process the computed nearest neighbors. DIMO presents novel methods for partitioning, searching, and storing high-dimensional datasets on distributed infrastructures that support the MapReduce programming model. We implemented DIMO and extensively evaluated it on Amazon clusters with up to 128 machines. We experimented with large datasets of sizes up to 160 million data points extracted from images.

B. Algorithm

Map reduce.

C. Advantages

DIMO produces high precision when compared against the ground-truth nearest neighbors and it can elastically utilize varying amounts of computing resources.

DIMO outperforms the closest system in the literature by a large margin (up to 20%) in terms of the achieved average precision, and requires less storage.

III. DISTRIBUTED KD-TREES FOR RETRIEVAL FROM VERY LARGE IMAGE COLLECTIONS

A. Description:

Distributed Kd-Trees is a method for building image retrieval systems that can handle hundreds of millions of images. It is based on dividing the Kd-Tree into a “root subtree” that resides on a root machine, and several “leaf subtrees”, each residing on a leaf machine. The root machine handles incoming queries and farms out feature matching to an appropriate small subset of the leaf machines. Our implementation employs the MapReduce architecture to efficiently build and distribute the Kd-Tree for millions of images.

B. Algorithm

Kd-Tree

C. Advantage

It can run on thousands of machines, and provides orders of magnitude more throughput than the state-of-the-art, with better recognition performance.

It experiments with up to 100 million images running on 2048 machines, with run time of a fraction of a second for each query image.

IV. MULTIDIMENSIONAL BINARY SEARCH TREES USED FOR ASSOCIATIVE SEARCHING

A. Description:

This paper develops the multidimensional binary search tree (or k-d tree, where k is the dimensionality of the search space) as a data structure for storage of information to be retrieved by associative searches. The k-d tree is defined and examples are given. It is shown to be quite efficient in its storage requirements. A significant advantage of this structure is that a single data structure can handle many types of queries very efficiently..

B. Algorithm

Searching algorithm.

C. Advantage

Various utility algorithms are developed; their proven average running times in an n record file are : insertion, O(log n); deletion of the root, 0 (n (k--1)/k) ; deletion of a random node, O(log n); and optimization (guarantees logarithmic performance of searches), 0 (n log n).

Search algorithms are given for partial match queries with t keys specified [proven maximum running time of O (n (k-t)/k)] and for nearest neighbor queries [empirically observed average running time of O(log n).] These performances far surpass the best currently known algorithms for these tasks

V. Comparison of Sequence Matching Techniques for Video Copy Detection

A. Description:

Video copy detection is a complementary approach to watermarking. As opposed to watermarking, which relies on inserting a distinct pattern into the video stream, video copy detection techniques match content-based signatures to detect copies of video. Existing typical content-based copy detection schemes have relied on image matching. This paper proposes two new sequence-matching techniques for copy detection and compares the performance with one of the existing techniques.

B. Technique used

Motion
intensity and color-based

C. Advantage

signatures are compared in the context of copy detection.
Results are reported on detecting copies of movie clips.

VI. Conclusion and Future Work

Distributing copy righted multimedia objects by uploading them to online hosting sites such as YouTube can result in significant loss of revenues for content creators. Systems needed tofind illegal copies of multimedia objects are complex and large scale. In this paper, we presented a new design for multimedia content protection systems using multi-cloud infrastructures.

The proposed system supports different multimedia content types and it can be deployed on private and/or public clouds.Two key components of the proposed system are presented.The first one is a new method for creating signatures of 3-Dvideos. Our method constructs coarse-grained disparity maps using stereo correspondence for a sparse set of points in the image. Thus, it captures the depth signal of the 3-D video, without explicitly computing the exact depth map, which is computationally expensive. Our experiments showed that the proposed 3-D signature produces high accuracy in terms of both precision and recall and it is robust to many video transformations including new onesthat are specific to 3-D videossuch as synthesizing new views. The second key componentin our system is the distributed index, which is used to match multimedia objects characterized by high dimensions. The distributed index is implemented using the Map Reduce frame-work and our experiments showed that it can elastically utilize varying amount of computing resources and it produces high accuracy. The experiments also showed that it out performsthe closest system in the literature in terms of accuracy and computational efficiency. In addition, we evaluated the whole content protection system with more than 11,000 3-D videos and the results showed the scalability and accuracy of the proposed system. Finally, we compared our system against the Content ID system used by YouTube. Our results showed that:(i) there is a need for designing robust signatures for 3-D videos since the current system used by the leading company in the industry fails to detect most modified 3-D copies, and (ii) ourproposed 3-D signature method can fill this gap, because it isrobust to many 2-D and 3-D video transformations.

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