Structuring Video Database using a Formal Methods Approach

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***Abstract*— Formal methods provide a foundation for many of the techniques that have changed the face of software development over the last two decades. Structuralizing video streams plays an important role in the processing of video. The basic structure for video is a hierarchical structure which consists of four kinds of components, namely frame, shot, scene, and video program. Formalizing supports the reliability and accuracy of the modeling language. Various researches have been done related to formal methods, video structure, and formalizing. This paper discusses the analysis of formal methods, applications, and structuring formal methods in video structure. The output from this study is, can determine the relation in video structure using the algebraic relation.**

Keywords-formal methods; video; video structure; formalization and formal specification.

I. INTRODUCTION

A multimedia database is a structure and organizes multimedia information for content retrieval [1]. It supports the various multimedia data types like texts, images, audio and video [2]. Among all these media types, video is the most challenging one [3]. This is because video combines all other media types' information into a single data stream. This is also because the challenges faced by researchers when implementing video increase even further when one moves from images to image sequences, or video clips. Also, every single video programs have their own rules and format.

Structuring the design is important in the development phase of the system. Our research is focused on structuring video using formal speficications. Video structure used segmentation-based techniques because individual shots or scenes logically meaningful units [4]. In addition, each shot or scene consisting of a sequence of frames and each frame can be considered as the image, allowing the use of the techniques available that have been developed to model and query image data. The increase in processing power and storage capabilities of modern computers has led to the development of new multimedia applications. The structures of a videos that are commercially available are not mutually compatible and interoperable. Furthermore, there are no database support video and view schema objects. These problems led to an effort to determine the specifications of a new structure for video federation. Previous researchers have outlined the issues related to video systems and discussed the technical challenges involved in developing a general-purpose video system. There are important issues in multimedia database management, including the development of formal modeling techniques for multimedia information, especially for video and image data. This structure should be rich with the ability to capture abstractions and semantics of multimedia information. By using formal methods, we hope to improve the structure of a video and can be more efficient for their content retrieval.

Some benefits expected from this study is the improvement of the quality of the video structure. The main objective of a formal specification notation is to assist the descriptions of video in order to make sure the structures are complete, consistent and unambiguous. Therefore, we propose an algebraic relation to design the relation in video structure.

This paper is organized as follows: The following section discusses research background on previous research and problem statement. In Section III, the video structure is explained. The formalizing of video structure and video algebra relation also discussed with the given example. In Section IV, elaborate on future works in this research. Finally, our conclusions are stated in Section V.

II. RESEARCH BACKGROUND

This study presents a formal methods as a proposed method to apply in the design and structuring video system. This method requires to forces an analysis of the system requirements at an early stage.

A. Previous Research

Structuring a video used several techniques, such as temporal and spatial [5] relations to design the database. However, structuring a video has a limitation, example in size and modeling the complex object in a wide range of types for indexing, searching and organization methods [6]. Therefore, the previous research tried to solve relation issues in multimedia database using the temporal specification. The temporal relations are to determine duration relations between multimedia objects. Djeraba and Briand [7] used the power of temporal Petri net to model the temporal and interactive relations. Another research into the structured temporal composition of multimedia is based on binary operators that represent some of the previously described relations between intervals of unknown duration has been done [5]. Other research uses a novel indexing technique

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based-on, efficient compression of the feature space for approximate similarity searching in large multimedia databases [8].

B. Problem Statement

A major problem encountered in the current database system is the lack of a natural way to define complex queries. This caused by the gap between the way users think and query language used in most systems. Multimedia data manipulation is not as easy as in a conventional database. The database structure can be represented with a clear video and can also be specified in requests for their content, but the main problem is to get the content of the video database. The difficulty arises because we must match the contents of the media data in the database with the content specified in the query. Each answer queries posted on media data, it must have an advanced technique in analyzing the contents of the data to get the different semantics associated with the media data [9]. The development of the new multimedia applications have been realized based on the improvements in processing and storage capabilities of latest computers [10]. Sometimes, available video structures are mutually incompatible and interoperability between them cannot be easily achieved. Furthermore, none of the approaches supports video and object view schemas. The issues on pertaining to video and discuss technical challenges involved in developing a general-purpose video system are specification requirements and the reference architecture. The salient issues in video system include development of formal modeling techniques for video information. These models should be high in capabilities for abstracting multimedia information and capturing semantics [6]. An important feature in accessing to databases of unknown structure is the presence of a schema repository where the database structure is explained, and a meta-model which provides a set of legal relationships and actions for entities in the database [10]. By using formal methods, we intend to improve the structure of video and it can be more efficient to retrieve their content.

III. VIDEO STRUCTURE

Video is the technology of capturing, recording, processing, storing, transmitting, and reconstructing a sequence of still images and representing scenes in motion. It helps to present the real world events to users. Video database provides random access to sequential video data. A basic video structure design it using segmentation-based techniques because individual shots or scenes logically meaningful units.

In order to help the users to retrieve relevant video materials, effectively at various semantic levels, a method defines a hierarchical structure of video material based on hierarchical data model. The structured proposes three steps of informal specification, as shown in Figure 1:

- Firstly, video is segmented into shots by shot boundary detection techniques [3].
- Secondly, key frames are selected to represent the shots.
- Finally, shots are clustered to scenes, based on the extracted shot features.

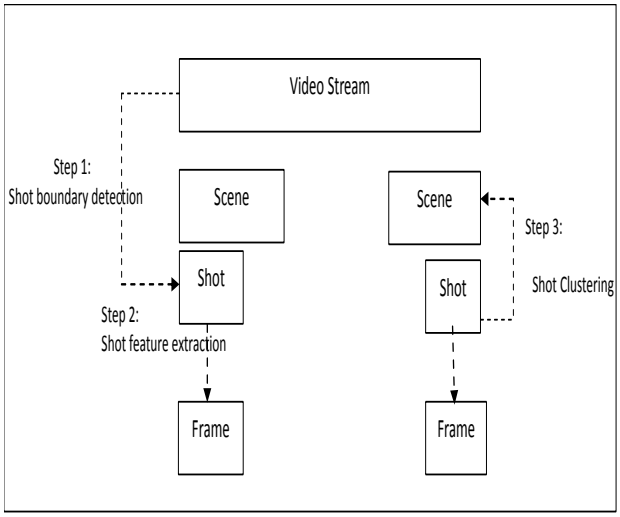

Figure 1. Video Structuring Process

A. Formalizing of Video Structure

Even though the others video do not have any specific content structure, as a scenes and videos, many videos have a fraction sequence of frames that is recorded from a single camera motion (shot) that can also express the content structure of the video [11]. A basic video structure contains scene, shot and key frame [12]. In Figure 2, a set of video structure is shown. The algebraic relationship model is illustrated through the statement mathematics [13]. A tuple is a set of relations and it structured in an easy form and this is called the schema relationships. However, this study is still in early stage. Before, we look further on video database system; we start on video basic structure.

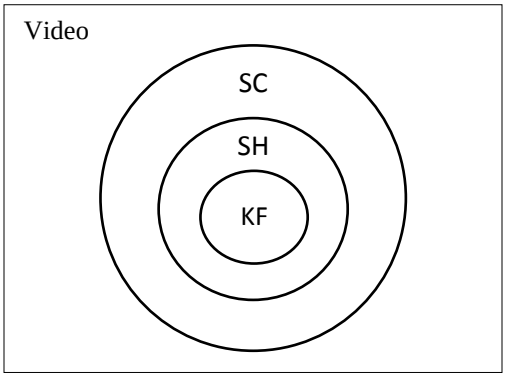

Figure 2. Set of Video Structure

A structure representation in Figure 2 can be described in the following algebraic relations.

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V (SC, SH, KF)
SH⊆ SC
KF ⊆ SH

where:
V: video
SC: sequence of shots.
SH: unbroken sequence of frames, and
KF: selected from a shot to represent the contents of the shot.

B. Video Algebra Relation

The basic structure of the video is a hierarchical structure. It is produced by the video program, scene, shot and key frame. A video program usually consists of a few scenes, and each scene includes one or more shots [11]. A key frame is a static image and minimum logic unit of video. A shot is an uninterrupted segment of video frame sequence with static or continuous camera motion. A scene is a series of shots that are sticked together from the narrative point of view. The definition below is to explain the structure of the video.

$\overline{MM}$ (V, SC, SH, KF)

MM : Multimedia Database

Every X_i in existence contains four data, such as represented below:

$\overline{MM}$ (V_i, SC_{ij}, SH_{jk}, KF_{km}) : *i, j,k,m* is an integer number.

Assume X_i is a video structure of i that exist in multimedia database (MM). Which consists of:

$V : \{<v,i>\} \mid i \in \mathbb{N} \wedge v_i \in MM\}$
V_i : is a video for video of the i
There exists a video(V_i) , in the video structure (X_i).

$SC : \{<<sc,i> v,j>\} \mid i \in \mathbb{N} \wedge <sc, v> \in SC_{ij}\}$
SC_{ij} : j^{th} Scene for the i^{th} Video (V_i)

$SH : \{<<sh,j> sh,k>\} \mid j \in \mathbb{N} \wedge <sh, j> \in SH_{jk}\}$
SH_{jk} : k^{th} Shot for the j^{th} Scene (SC_j)

$KF :\{<<kf,k> sh,m>\} \mid k \in \mathbb{N} \wedge <kf, k> \in KF_{km}\}$
KF_{km} : m^{th} Key Frame for the k^{th} Shot (SH_k)

There exists Scene (SC_j), Shot (SC_k) and Key Frame (KF_m) in the video (V_i).

C. Example

In this section, we are given an example of notation representation based on the hierarchical structure of the video. In Figure 1, we showed that in Video (V_1) there are two scenes, two shots and two key frames, and the algebra relation are:

$V_1 \longrightarrow SC_{1j}=\{1,1..2\} \longrightarrow SH_{jk}=\{1..2,1..2\} \longrightarrow$
$KF_{km}= \{1..2,1..2\}$

If i=1, j=2, k=2 and m=2, so:

$V_1 = \{SC_{1,F}, SH_{1,1}, KF_{1,1}\}$
$= \{SC_{1,2}, SH_{2,1}, KF_{2,1}\}$

$\forall X_i \exists MM =\{V_1, SC_{1,1..2}, SH_{1..2,1..2}, KF_{1..2,1..2}\} \mid X_i \in MM$

This shows that, in Video (V_1), there are two scenes that were identified by integer value j, Scene ($SC_{1..2,1..2}$). There also had two shots that were identified by an integer value k, Shot ($SH_{1..2,1..2}$). Lastly, key frame identified by integer m, ($KF_{1..2,1..2}$).

In general:
$X : \{ X_i \mid i \in I \wedge \forall X_i \in MM \}$

where:
X : exists in multimedia database (MM)
I : integer number ($1 \leq I \geq n$)

SX_i represents the total of video in multimedia database and it may increase depending on the circumstances and situation of an existing system. Therefore:

$$SX_i = \sum_{i=1}^{n} X_i$$

IV. CONCLUSION AND FUTURE WORK

Structuring video is an important step in video data management. The basic video structure is used hierarchical structure. The structured modeling approach has evolved into segmentation-based approach. In this paper a mathematical notation used to describe the structure of the database video more clearly. It can explain the relation between the scene, shot and key frame. Mathematical notation is a combination of delegated some elements in the structure. From the representation algebraic relations, the structure of video extracted can be developed further. The video relation algebra generated will help in the process to design new structures of video database using formal methods. By using formal methods, hope can improve the structure of video and can be more efficient to retrieve their content.

Based on Figure 3 below, this paper focused on early stage in formal specification methods. We started with algebraic relation to identify the relation of set in video

structure. An algebraic relation is an algebraic structure equipped with the Boolean operations [13]. Formal specifications have two types are property-oriented and model oriented [14]. Algebraic relation is part of property oriented. Property oriented is state desired properties in a purely declarative way. Relation algebraic will be written in the form of a schematic for proving and verifying. A schema is essentially the formal specification analogous to programming language subroutines that are used to structure a system, where the schemas are used to structure a formal specification. Z [15] is physically powerful on sets and functions. Formal proving is a complete argument of mathematical representation and it is used to validate statement about system description. Formal proving can be done using theorem proving tools, i.e., Z/Eves [15].

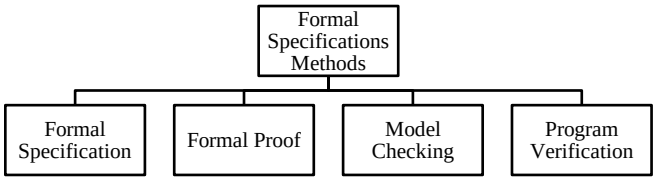

Figure 3. Formal Specification Methods [16].

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REFERENCES

[1] S.K. Jalal, "Multimedia Database: Content and Structure", Workshop on Multimedia and Internet Technologies, 2001.

[2] F. Mohamed, M.N.A. Rahman, and M.L. Abdullah, "The development of temporal-based multimedia data management application using web services", in Intelligent Systems Design and Applications (ISDA), 2011 11th International Conference on. 2011.

[3] L.S. Affendey, A. Mamat, H. Ibrahim, and F. Ahmad, "Video Data Modelling To Support Hybrid Query", IJCSNS, 2007. 7(9): pp. 53.

[4] B. Günsel and A.M. Tekapl, "*Content-based video abstraction"*, In Proceedings of IEEE International Conference on Image Processing, 1998: pp. 128-131.

[5] A. Duda and C. Keramane, "Structured temporal Composition of Multimedia Data", in iw-mmdbms. 1995.

[6] A. Ghafoor, "Multimedia Support Infrastructure (MSI)", National Science Foundation 2006 [cited 2013 20 November]; Available from: http://www.cs.purdue.edu/.

[7] C. Djeraba and H. Briand, "Temporal and interactive relations in a multimedia database system", in Multimedia Applications, Services and Techniques—ECMAST'97. 1997, Springer. pp. 457-473.

[8] E. Tuncel, H. Ferhatosmanoglu, and K. Rose, "VQ-index: An index structure for similarity searching in multimedia databases", in Proceedings of the tenth ACM international conference on Multimedia. 2002: ACM.

[9] D.A. Keim and V. Lum, "Visual query specification in a multimedia database system", in Proceedings of the 3rd Conference on Visualization'92. 1992: IEEE Computer Society Press.

[10] D. Bećarević and M. Roantree, "A metadata approach to multimedia database federations", Information and Software Technology, 2004. 46(3): pp. 195-207.

[11] C.-j. Fu, G.-h. Li, and K.-x. Dai, "A framework for video structure mining", in Machine Learning and Cybernetics, 2005. Proceedings of 2005 International Conference on. 2005: IEEE.

[12] T. Catarci, M.E. Donderler, E. Saykol, O. Ulusoy, and U. Gudukbay, "BilVideo: a video database management system", MultiMedia, IEEE, 2003. 10(1): pp. 66-70.

[13] N.L. Sarda, "Algebra and query language for a historical data model", The Computer Journal, 1990. 33(1): pp. 11-18.

[14] E.M. Clarke and J.M. Wing, "Formal methods: State of the art and future directions", ACM Computing Surveys (CSUR), 1996. 28(4): pp. 626-643.

[15] J.A. Jusoh, M.Y.M. Saman, and M. Man, "Formal Validation of DNA Database Using Theorem Proving".

[16] J. M. Wing, "A Specifier's introduction To Formal Method", Defense Advanced Research Project Agency (DOD), 1990.

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