Comprehensive Performance Comparison of Energy Compaction Techniques for CBVR with Transformed Videos

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Abstract - In modern days, multimedia search engines retrieves the images based on the features like color, edge, shape etc. The retrieval of multimedia based on the contents is called as content based retrieval (CBR). During two decades back retrieval systems accesses, updates and retrieves the multimedia based on the annotations. But it was tedious and human interfering task. Thus there was need of content base retrieval. The retrieval of videos based on the contents of video like color, key frames, motions, scenes and clips etc is called as Content Based Video Retrieval (CBVR). In the proposed work the research has been to improve the accuracy thus efficiency of retrieval system by using the transformations and feature size reduction. he proposed CBVR methods using Transformed video are proved to be better and faster using test bed of 500 variable size videos spread across 10 video categories. Focus of experimentation is on feature reduction with two different techniques of energy extraction methods.

Keywords — Content Based Video Retrieval, Digital videos, Energy Compaction, Feature Extraction, Hybrid Wavelet Transforms, Orthogonal Transforms.

I. INTRODUCTION

With the era of technology, the demand of multimedia usage has reached to infinity with increased ongoing demand of fast retrieval. Accurate, precise and concise retrieval of information as per demand of the user is need of the day. Existing multimedia search engines like Google, Yahoo Bing etc uses the annotations or sticky notes of multimedia for searching purpose which has very high error rate [1]. From all types of multimedia like text, video, audio, still image and animation; video is most challenging for access, indexing and retrieval because of its length and unregulated format. Even there is requirement of retrieval of videos/images from diverse field like medical, agriculture, education, politics, history, geography, surveillance, forensics and fashion with less time and high accuracy [2].

The objective of any Content Based Retrieval System is to improve the efficiency of the system with all dimensions of storage, accuracy and speed. Dynamic video retrieval system provides the path to handle, update, access and retrieve the video database in accurate, faster and flexible manner. Efficiency of CBVR system can be enriched with three axes. The First axis is accuracy. Next is storage and last but not least is speed of retrieval. Thus the efficiency of CBVR lies in the improvement of retrieval accuracy, reduction in storage requirements and minimization of retrieval time.

II. REVIEW OF LITERATURE

Multiple ways are existing in literature for retrieval based on the actual contents of the video. Those approaches are based on various techniques and choice of desired video components for feature extraction. For video retrieval diversified video components like video segments, optical key frames, color, motion and sequence are turned out to be very useful for video retrieval methods [3]. Video consists of sequence of images with a time gap. Thus image is integral part of video. Exhaustive research is available in field of image retrieval.

The basic components of content based image retrieval system is suggested by Xiaohong et al. [4] and pointed out the semantic based image retrieval method. The method of feature weight assignment operators with combined features of color and texture is introduced and recommended by Liu et al. [5]. A new technique based on predominant colors features in the foreground is experimented by Krishnan et al. [6].

Transformation of images from spatial domain to frequency domain with help of multiple orthogonal transforms is used for content based image retrieval. An image retrieval technique of means of rows and columns and combination of them for feature extraction with image fragmentation which is then followed by discrete cosine transformation on them is proposed by Kekre et al. [7].

Feature selection is very important phase of video retrieval system. It helps in curtailing down the space required to cache the video. Orthogonal transforms are used widely to excerpt the distinguishing feature of the images [8]. Multiple transforms like Sine, Cosine, Haar, Walsh, Hadamard and Kekre are available out of them Haar and Walsh transforms have shown better performance for Content Based Video Retrieval [9,10]. Wavelets which are output of convolution of orthogonal transforms shows the better result in reduction in feature vector size in image retrieval [11].

Wavelet transforms has proven to be better than orthogonal transforms in many applications like compression, indexing and classification etc [12]. Hybrid Wavelet Transform is result of combination of Kronecker product and convolution of two constituent orthogonal transforms. With retrieval systems Hybrid Wavelet Transform are shown substantial results [12, 13]. Moreover from combinations of multiple orthogonal transforms, hybridization of Cosine and Walsh showed better performance in Content Based Video Retrieval [12] for partial energies. Wavelet transforms and Hybrid wavelet transforms has outperforms the constituent orthogonal transforms and proven better in many applications [14, 15].

A. *Fractional Energy*

The fractional energies have shown better performances in frequency domain when there is need to deal with space and speed related issues [16]. Different fractional energy coefficients i.e. 100 %25%, 6.25 % and 1.5625 % are obtained by resizing video frame into 256 x 256 dimension and selecting only 128 x128 as 25 %,64 x 64 as 6.25 % and 32 x 32 as 1.5625 % as block sizes for energy compaction (feature size reduction).

On individual image an orthogonal transform is multiplied and transformed features of images are obtained. In this case the size of feature vector is N x N for every transform. The effect of fractional energy distribution decides the video content in the clip and computations involved in the block processing. It can be viewed as shown in Figure 1. With reduction in the percentage of transformed energy the features are also reduced, The T indicates the transform applicable for energy extraction.

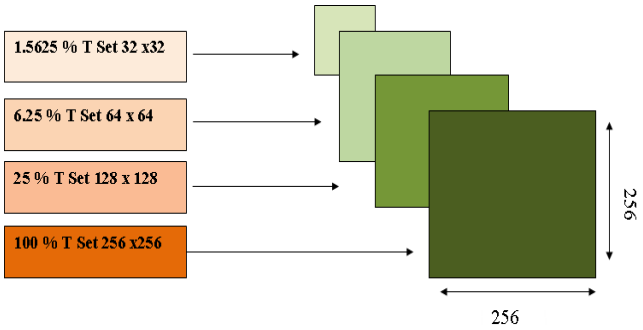

Figure 1. Feature vector extraction with Fractional energy

B. *Partial Energy*

Partial energy extraction has already proven effective and efficient for image retrieval [17]. Partial energy extraction from complete energy coefficients is a multiple steps process [18] as follow.

a. Generation of average energy matrix
b. Calculating a summed energy matrix
c. Creating a Partial energy coefficient table

Steps are summarized in a Figure 2.

In the partial energy extraction method all images are transformed to frequency domain by using orthogonal transforms. Then resultant transformed images are aggregated up for averaging. Cumulative aggregation of all images are calculated and then only required energy pixels are considered.

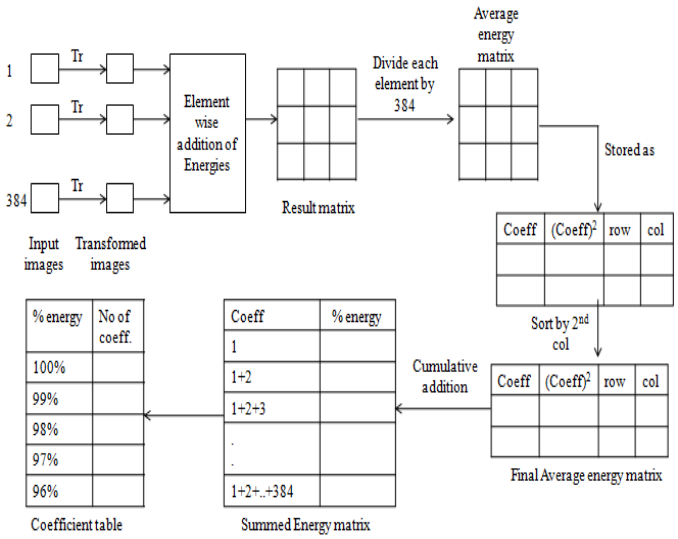

Figure 2. Energy Compaction using partial energy [12]

III. PROPOSED CBVR TECHNIQUE

A. Block Diagram

Architectural block diagram of proposed Content Based Video Retrieval system is as given in Figure 3. CBVR includes two modules – Registration and Query Execution Phase. In registration phase, complete database is built on the partial energy of transformed. For query execution phase the same as of registration phase feature extraction steps are performed on the query image and the features of query videos are compared with the database to get most relevant match.

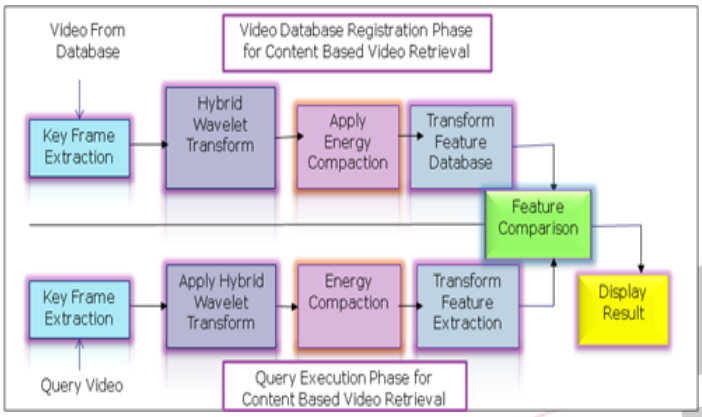

Figure 3. Block Diagram for Transformed Content Based Video Retrieval with energy compaction

In the proposed system, the feature extraction is done using two methods – fractional and partial energy extraction techniques.

B. Feature extraction using fractional energy

Figure 4 details about feature vector generation using fractional coefficients. In fractional energy extraction method a complete video is considered for the 100% energy and the division of complete energy is done in step by manner for 25%, 6.25 % and 1.5625 % energy.

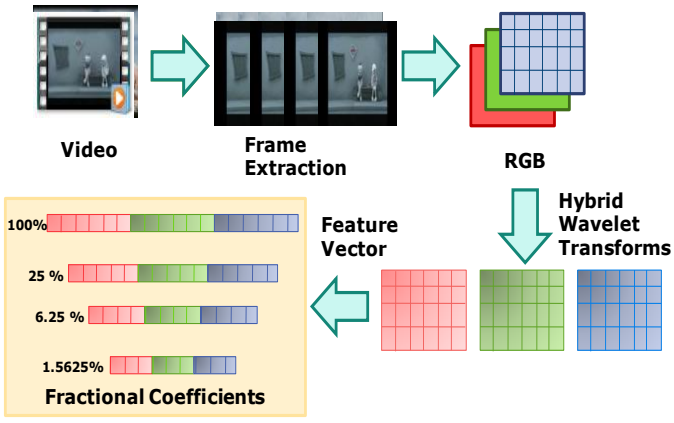

Figure 4. Feature vector generation with fractional energy coefficients of transformed visual video contents

Hybrid Wavelet Transform is generated from the constituent orthogonal transform in the proposed work and then this HWT is applied on the videos to extract the energy coefficients. Consequently all the coefficients are considered in CBVR technique. With fractional energy method, 25%, 6.25 % and 1.5625 % energy is considered in consecutive research and CBVR accuracy is noted down. Performance of two orthogonal transforms- Cosine and Haar are compared with Cosine-Haar Hybrid Wavelet Transform with fractional energy.

C. Feature extraction using partial energy

The next research is carried out with partial coefficients. Partial coefficients are considered by taking help of already built reference Full Average Energy Matrix. This experiment is also carried with Haar, Cosine and Hybrid Wavelet Transform of Consine-Haar Transform.

Steps for generating the partial coefficients are given below.

1. Fix the partial energy percentage to be considered for the experiment. For example 99%, 98%, 90% or 85% etc.
2. With help of Full Average Energy Matrix, consider the number of pixels required for the considered percentage of energy.
3. Pixel location can be obtained from the reference table.
4. Energy of the pixel is saved as feature vector.

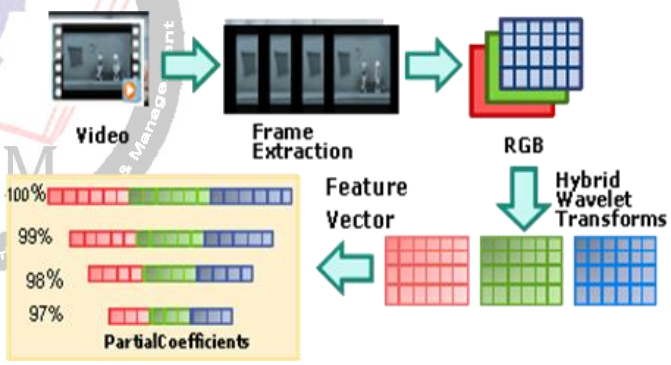

Figure 5 Feature vector generation with partial energy coefficients of transformed visual video contents

99%, 9%, 97%, 96%, 95%, 90% and 85% partial energy coefficients are used to build the feature vector database and do the experimentation of CBVR.

D. Performance Evaluation

The proposed methodology has used the accuracy as a tool to experiment the effectiveness of the research. Accuracy is a statistical comparison parameter for comparing the experiments of the CBVR.

$$Accuracy = \frac{\{Number\ of\ relevant\ videos\ \ retrived\}}{\{Total\ number\ of\ videos\ retrieved}$$

IV. EXPERIMENTATION ENVIRONMENT

Proposed research has been worked out on the MATLAB. All results are experimented on the CORE i3 processor.

Dataset of experimentation has 500 Videos. These all 500 videos are scattered in 10 categories and each category has diverse 50 videos. Figure 6 shows the snapshot of the video dataset.

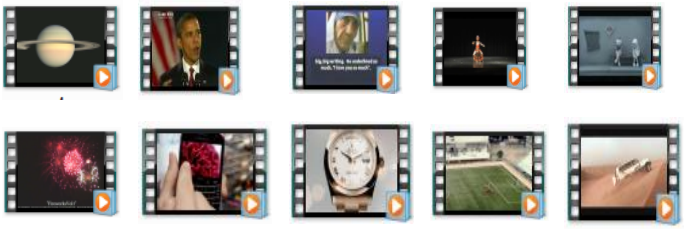

Figure 6. Samples from the Categories of Video Dataset

From figure 6 it can be seen that different 10 categories of Videos are considered. Total 50 videos of each category is taken. Totally database is considered of 500 videos.

V. RESULTS AND DISCUSSION

Retrieval results with average accuracy are shown in Figure 7 for 100%, 25%, 6.25%, 1.5625%, 0.391%, 0.098% and 0.024% fractional energies. It can be observed that when be reduced down the energy considered we get more accurate results. Highest accuracy is observed for the CBVR with Cosine-Haar Hybrid Wavelet Transform for 0.024% fractional energies.

The average accuracy values for Transformed Content Based Video Retrieval for Haar, Cosine and Cosine-Haar Hybrid Wavelet Transform with 100%, 25%, 6.25%, 1.5625%, 0.391%, 0.098% and 0.024% fractional energy coefficients are shown in figure 7.

The conclusion from the experimentation is when the fractional coefficients are considered accuracy of CBVR is more. Maximum accuracy is obtained from 0.024% fractional energy with Cosine-Haar Hybrid Wavelet Transform.

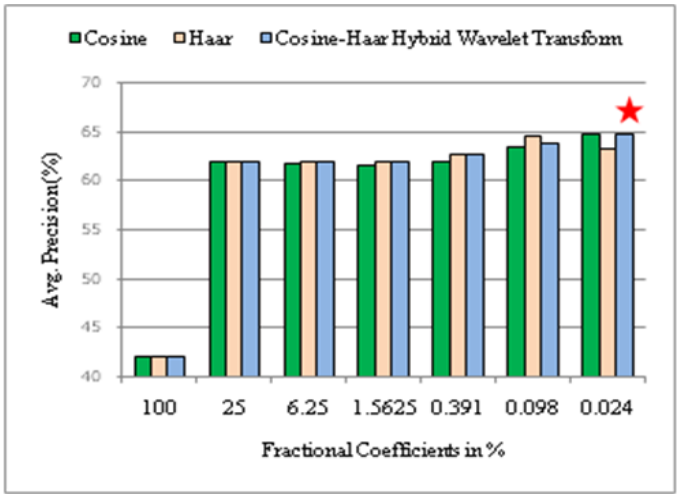

Figure 7. Performance of Cosine, Haar and Hybrid Wavelet Transform with energy compaction for CBVR

From the Figure 8, it can be easily observed that higher accuracy is given by Cosine-Haar Hybrid Wavelet Transform for 0.024% fractional energies indicating better performance among considered fractional energies.

From the experimentation of fractional energy coefficients and Haar, Cosine and Haar-Cosine Hybrid Wavelet Transform, it can be observed that there is increase in accuracy using energy compaction with fractional energy coefficients which leads to increase in retrieval efficiency.

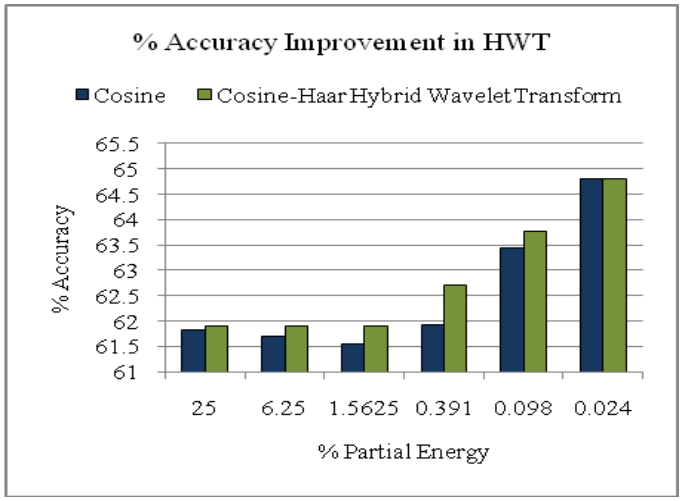

Figure 8. Performance of Cosine, Haar and Cosine-Haar Hybrid Wavelet Transform based CBVR with 0.024% energy

Next experimentation is carried out for the partial energy extraction. Haar, Cosine, Cosine-Haar HWT and Cosine-Walsh HWT transforms are applied on individual videos and then partial energy is excerpted from the transformed contents. The experimentation is carried out with City Block Metric.

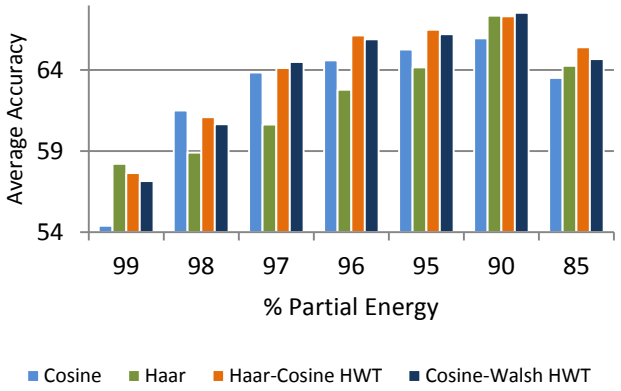

Figure 9. Performance of Cosine, Haar, Cosine-Haar HWT and Cosine-Walsh HWT based CBVR with different percentage of partial energies

Figure 9 summarizes the performance given by constituent transforms and hybridization of them for different partial energy percentages considered in proposed transformed content based video retrieval. It is seen that Cosine-Walsh Hybrid Wavelet Transform is performing best for 90% partial energy.

Till now the increase in accuracy is observed for CBVR with both energy compaction techniques. But now the observation related to reduction of feature size is summarized. Its is observed from the Table I that with reduction in percentage of fractional energy coefficients used , there is huge cutback in feature vector size. At 0.024% of energy there is 99.976% rebate in feature vector size.

Table I: Feature Vector Size and % Fractional Energy

Feature Vector Size	% Fractional Energy Coefficients	% Reduction in Feature vector size
$(N \times N \times 3)$	100	0
$\left(\frac{N}{2} \times \frac{N}{2} \times 3\right)$	25	75
$\left(\frac{N}{4} \times \frac{N}{4} \times 3\right)$	6.25	93.75
$\left(\frac{N}{8} \times \frac{N}{8} \times 3\right)$	1.5625	98.4375
$\left(\frac{N}{16} \times \frac{N}{16} \times 3\right)$	0.391	99.609
$\left(\frac{N}{32} \times \frac{N}{32} \times 3\right)$	0.098	99.902
$\left(\frac{N}{64} \times \frac{N}{64} \times 3\right)$	0.024	99.976

Its is observed from the Table I that as percentage of fractional energy coefficients used is reduced, there is huge reduction in feature vector size. At 0.024% of energy coefficient there is 99.976% reduction in feature vector size.

Reduction in feature vector size in CBVR with partial energy is given as in Table II.

Table II: Feature Vector Size and %Partial Energy

Wavelet Transforms	Energy considered to form feature vector	Number of coefficients considered to form Feature vector	Percentage Reduction in size of Feature vector (in %)	Accuracy (in %)
Cosine	90	32	99.51	65.95
Haar	90	43	99.93	67.36
Walsh	90	37	99.94	67.26
Haar-Cosine	90	29	99.96	67.32
Cosine-Walsh	90	30	99.95	67.53

From table II, it is can be observed that for the best performing Cosine-Walsh Transform at 90% of partial energy, only 30 coefficients are required compared to 65536 coefficients of 100% energy. Thus there is huge reduction of feature vector size. Hence the goal of reduction in size complexity is achieved through reduction in feature vector size with 90% of partial energy coefficients and highest accuracy of retrieval. When there is reduction in feature vector size then there is less number of comparisons required for matching the query video with database videos which indirectly improves the speed of retrieval. Hence one of the aims of CBVR of improving the speed of video retrieval is also achieved with partial energy coefficients.

In the proposed experiments we have seen, with fractional energy Cosine-Haar Hybrid wavelet transform outperforms the cosine transform. With partial energy Cosine-Walsh hybrid wavelet transform outperforms all other hybrid wavelet transform. Figure 10, discussed the comparison of these two best performing techniques with respect to percentage of retrieval accuracy.

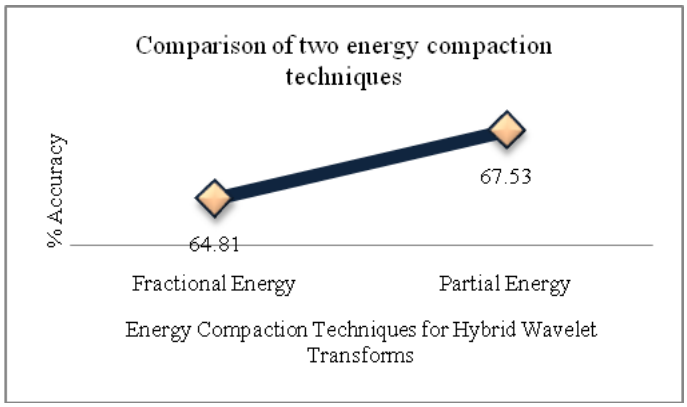

Figure 10: Comparison of Hybrid Wavelet Transform with energy compaction technique

From the comparison of two best performing hybrid wavelet transform with respect to accuracy after applying energy compaction, CBVR with Partial energy outperforms fractional energy giving the 14.75% improvement in accuracy. Thus proposed partial energy compaction technique is more efficient than fractional energy compaction technique for Content Based Video Retrieval (CBVR).

Proposed CBVR method targets at transformed visual contents of Video. Different orthogonal transforms are used to increase the efficiency thus accuracy of the CBVR. Further the reduction in size to save the features of the video can be achieved by using the energy compaction to transformed contents of the videos. In proposed method energy compaction is achieved through two ways viz, fractional energies and partial energies.

Fractional energies considered are 100%, 25%, 6.25%, 1.5625%, 0.391%, 0.098% and 0.024%. Energy compaction is achieved with these fractional energies for Cosine, Haar and Hybrid Cosine-Haar Transform. After the analysis of experimentation of CBVR using fractional energies, it is concluded that Hybrid Wavelet Transform performs best with 99.976% reduction in feature vector size, accuracy of 64.81% and huge reduction in feature extraction complexity of 75%. Thus the efficiency of CBVR is improved using energy compaction by considering fractional energies of hybrid wavelet transformed contents of the video.

In the next proposed method the partial energies considered are 100%, 99%, 98%, 97%, 96%, 95%, 90% and 85% with orthogonal transforms and hybrid wavelet transforms (HWT). With given experimentation of CBVR and partial energy, cosine-Walsh hybrid wavelet transform results best for 90% of partial energy giving 67.53% of accuracy with highest reduction in feature vector size of 99.95%. The number of features considered for Cosine-Walsh HWT is only 30.

VI. CONCLUSION

With the increase in advancement of network and storage technologies there is huge amount of video data getting available. To manage, store, index and retrieve this bulky video data is big challenge in the field of retrieval. Experimentation proposed an efficient method of Content Based Video Retrieval (CBVR). Efficiency of retrieval relates to increase in accuracy, speed and reduction in space. Proposed method has considered all three aspects of efficiency.

With comparison of Cosine-Haar HWT with fractional energy and Cosine-Walsh HWT with partial energy it is proved that partial energy compaction outperforms the fractional energy.

The objective of proposed experimentation of achieving efficient Content Based Video Retrieval (CBVR) method using energy compaction of transformed content is achieve with Cosine-Walsh Hybrid Wavelet transform at 90% partial energy which results into boost in accuracy, speed of retrieval and reduction in space.

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