효율적인 장면전환 검출을 이용한 비디오 브라우징 서비스

Video Browsing Service Using An Efficient Scene Change Detection

신 성 윤* 이 양 원**
Seong-Yoon Shin Yang-Won Rhee

요 약

최근 디지털 비디오는 인터넷을 통해 제공되는 매우 중요한 정보 미디어의 하나이며 멀티미디어 분야에서 매우 중요한 역할을 수행하고 있다. 본 논문에서는 웹 상에서 실시간 사용자 인터페이스를 통해 비디오 내용 검색과 브라우징을 제공하는 비디오 브라우징 서비스를 제시한다. 비디오 시퀀스의 장면 분할과 키 프레임 추출을 위해서 RGB 컬러 히스토그램과 χ^2(카이 스퀘어) 히스토그램을 합성한 효율적인 장면 전환 검출 방법을 제안한다. 이렇게 추출된 키 프레임들은 물리적인 방법과 논리적인 방법에 따라 색인화 된다. 이 시스템은 또한 비디오카세트리코더(VCR)가 갖고 있는 비디오 편집과 검색 기능을 포함한다. 비디오 브라우징을 위하여 날짜, 분야, 그리고 주제의 세 가지 요소가 사용되며, 비디오 브라우징 서비스는 아파치 웹서버에서 MySQL, PHP, 그리고 JMF를 이용하여 구현된다.

Abstract

Recently, Digital video is one of the important information media delivered on the Internet and playing an increasingly important role in multimedia. This paper proposes a Video Browsing Service(VBS) that provides both the video content retrieval and the video browsing by the real-time user interface on Web. For the scene segmentation and key frame extraction of video sequence, we proposes an efficient scene change detection method that combines the RGB color histogram with the χ^2(Chi Square) histogram. Resulting key frames are linked by both physical and logical indexing. This system involves the video editing and retrieval function of a VCR's. Three elements that are the date, the field and the subject are used for video browsing. A Video Browsing Service is implemented with MySQL, PHP and JMF under Apache Web Server.

1. Introduction

Digital video is the most challenging and common media type of all the media types-text, image, graphic, audio and video, as it combines all the other media information into a single data stream[1]. In recent years, the enhancement of data compression and computer network technology has enabled the authorization of a large amount of digital video content.

However, a large amount of digital video that consisting of a great many frames is not easy to handle. We must have an attractive means to handle our large amount of digital video. It is often difficult to find both the appropriate video file and the portion of the video that is of interest[2]. The users may just want to see some interesting sequence of frames when they watch a video.

In general, for the efficient handling of video, such as retrieval, editing and browsing of video contents, a video stream is divided into a number of scenes or shots.

Scene change detection method divides the original video into a number of scenes or shots,

* (주)네트플러스 동영상연구팀 연구원
syshin@cs.kunsan.ac.kr
** 군산대학교 컴퓨터정보과학과 교수
ywrhee@cs.kunsan.ac.kr

and extract the key frames[3,4]. Key frames can be used to distinguish videos from each other, summarize videos, and provide access points into them[4]. Key frames provide a suitable abstraction and framework for video indexing, browsing and retrieval[5]. A key frame is representative of a scene or a shot, so some researchers call it representative frame[6] as well. However, it is difficult to determine the best representative frame that present the best information of a scene or a shot.

As a result of the great development in video compression and transmission, the use of digital video in multimedia systems and on the Internet is becoming universal. In order to make good use of the valuable multimedia resource, there is a need for content-based indexing, retrieval and browsing of video.

This paper proposes a Video Browsing Service (VBS) based-on scene change detection. A new scene change detection method that combines the RGB color histogram with the x^2(Chi Square) histogram proposed. Extracted key frames are indexed both physically and logically. Video retrieval system involves the function of a VCR(Video Cassette Recorder). Video browsing consists of three functions; retrieval, browsing and playing of the video scenes.

The remainder of the paper is structured as follows. In Section 2, related work in key frame extraction is reviewed. In Section 3, our new scene change detection method for key frame extraction and video indexing is described. In Section 4, the video browsing system is presented. Experimental results are given in section 5. And, in Section 6, concluding remarks are described.

2. Related Work

In video retrieval and browsing, key frame extraction is a very important and basic technique. Many researchers have developed key frame extraction methods for efficient video handling and management.

Shot boundary detection segment the video stream into shots, then the first frame of each shot is the shot's key frame[7]. There are some of the significant shot boundary detection techniques, such as the pixel differences, the statistical scene change detection, the compression differences, and the edge tracking etc.

Visual contents of the video stream are used for key frame extraction based on shot detection. This visual contents are color and motion features for content-based video browsing [8]. In color feature based criteria, the first frame will be selected as the first key frame. As a reference frame, the distance between this frame and current frames are compared. If the distance exceeds a threshold, the current frame is used as a new key frame. In motion feature criteria, the first and last frame will be selected in a zooming, and frames depending on overlapped scale in panning are extracted as key frames.

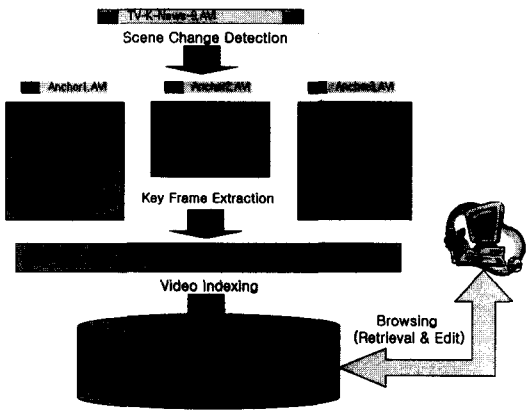
Wolf has proposed the key frame extraction method based on motion analysis [9]. This method analyzes the optic flow and the motion metric function. The motion metric is used as a function of time to select key frames at the local minima of motion.

Audio and image are used for key frame selection[3]. Key frames are selected using the keywords of audio, the image information and the camera motion. However, this technique is difficult to implement automatically, since processing area is widely spread.

Other key frame extraction methods are following. There are frame difference[10,11], color histogram method[12,13,14,15], video object segmentation and tracking[16.17], edge distance[18] and wavelet measure-

ment[19].

This paper proposes a Video Browsing Service (VBS) based on efficient scene change detection method using both the color information and the x^2 histogram difference. Figure 1 shows VBS overview.



(Figure 1) VBS Overview.

3. Scene Change Detection

3.1 Color Histogram and x² Histogram

This section show scene change detection(or shot detection) methods that have used generally. Among the many methods, we will review the color histogram and ^{2} histogram that have used by many researchers of multimedia modelling, since this method were of the basis for many histogram differences.

In general, color histogram difference is widely used for the detection of the abrupt scene change [12,13,14,15]. Given a frame Ii and a subsequent frame Ii+1, Hi(k) is the k-th histogram value of the i-th frame, and histogram difference can be described as following:

$$d(I_i,\ I_{i+1}) = \sum_{k=0}^{N-1} |H_i(k) - H_{i+1}(k)| \qquad (1)$$

In Equation (1), if we use 256-color level, 256 histogram values of frame Ii and Ii+1 and differences of histogram values for each bin are computed. If the sum of all differences exceeds a threshold, scene change is detected. This method is simple, but sensitive to changes of motion and brightness.

And also, color histogram difference can be computed by individually separation of RGB color space. This can be described as following:

$$\begin{aligned} d_{RGB}(I_i,\ I_j) = \frac{1}{3} \sum_{k=1}^{n} (& |H_i^r(k) - H_j^r(k)| \\ & + |H_i^g(k) - H_j^g(k)| \\ & + |H_i^b(k) - H_j^b(k)|) \end{aligned} \qquad (2)$$

Because each color histogram value is computed individually, this method is more complex than the method of Equation (1), but more flexible than it.

A x^2 Histogram gives considerably better results than the color histogram and template matching[15]. Therefore, many researchers apply this method to his study and projects. The x^2 histogram difference can be described as following, where Hi(k) means the k-th bin value of the i-th histogram :

$$d(I_i,\ I_j) = \sum_{k=1}^{n} \frac{(H_{i(k)} - H_{j(k)})^2}{H_{j(k)}} \qquad (3)$$

Above equation can be transformed as following:

$$d(I_i,\ I_j) = \sum_{k=1}^{n} \sqrt{H_{i(k)}{}^2 - H_{j(k)}{}^2} \qquad (4)$$

This method is tolerant to local motion of object and more efficient than other methods of feature extraction. However, this method is also sensitive to brightness.

3.2 A Proposed Histogram

This paper proposes a new scene change detection

method that combines the RGB color histogram with the x^2(Chi Square) histogram. Histogram difference will be computed by converting the RGB color space into the YIQ space. This can be described as following:

$$d(I_i, I_j) = \sum_{k=1}^{n} \left(\frac{(H_i^r(k) - H_j^r(k))^2}{H_i^r(k)} \times 0.299 + \frac{(H_i^g(k) - H_j^g(k))^2}{H_i^g(k)} \times 0.587 + \frac{(H_i^b(k) - H_j^b(k))^2}{H_i^b(k)} \times 0.114 \right) / 3 \quad (5)$$

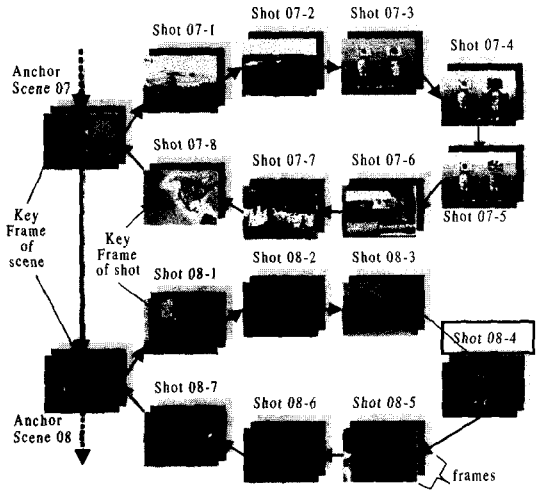
This method is more efficient and flexible than other methods, since it is tolerant to the motion of camera and objects, and good for detection of abrupt and gradual scene change.

As a result of this scene change detection method, key frames are extracted at the point when the great frame difference occurred. That is, when the histogram difference exceeds a given threshold, a first frame at just point selected as a new key frame and this key frames are key frames of shots.

3.3 Scene and Shot Boundary

Scene change detection extracts key frames and separates shots from video streams. That is, these key frames are key frames of shots, and shot is consist of subsequent frames. In news video, an anchor frame is representative of an item of news. Therefore, each anchor frame is the key frame of each news scene that consist of several shots. Figure 2 shows this scene and shot structure.

Consequently, the key frame extracted by scene change detection is the key frame of the shot, and shot consist of subsequent frames between current and next key frame. Anchor frame is the key frame of the scene, and scene consist of subsequent shots between current anchor shot and next anchor shot.

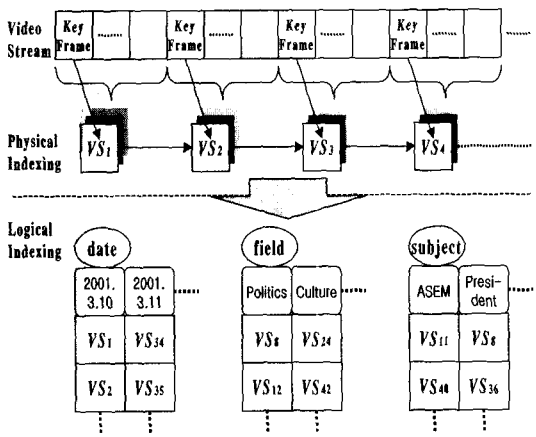


(Figure 2) Scene and shot structure

4. Video Browsing Service

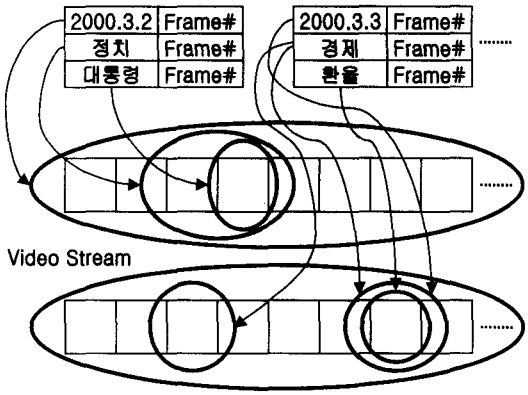
4.1 Indexing of Key Frames

Key frame indexing is a fundamental process for the retrieval and browsing of video. Key frame indexing has performed by both physically and logically as Figure 2.



(Figure 3) Physical and logical indexing.

Physical indexing links together key frames by the temporal sequence of video scenes. And logical indexing links together key frames by the date, the field, or the subject, for the efficient retrieval and browsing of the user's interest.



(Figure 4) Logical indexing for retrieval

Figure 4 shows detailed logical indexing structure for retrieval. Therefore, users can select the required date, field and/or subject, then the proper scene is accessed real-timely and user can view it immediately.

4.2 Video Browsing

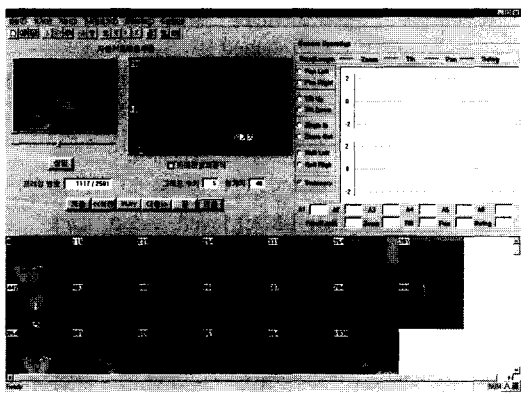
Most users may want to use fast forward and rewind function as in the VCR's. When users will play and watch a video, they may just want to skip over some uninteresting sequence of frames. Therefore, video editing system involves the function of a VCR and provides the video editing services, such as the frame segmentation and merge, the concatenation of frames and scenes, and the deletion of frames and scenes.

In Web, the Video Browsing Service consists of three parts; they are retrieval, browsing and playing of the video scenes. For the retrieval of the video scene, the three retrieval elements that are the date, the field and the subject are used. Each of three elements is used separately or compositively for the retrieval. In the browsing of the video scene, retrieved scenes are viewed and listed. Also, the information of the selected scene and frame is described in detail. The video playing part can play the retrieved or the selected video scene and present all information of the currently playing video scene.

5. Experimental Results

A study has been carried out using three different News videos of three different TV Broadcasting Stations. Three Broadcasting Stations are KBS, MBC and SBS. In the experiment, the original video streams are AVI format and exactly 300 second long. And video streams are captured by 5 frames per second, then frames are normalized on size of 400 x 300 pixel.

Figure 5 shows key frame extraction and editing system. When a captured input video is selected and threshold is given from user, key frames are extracted. Among the extracted key frames, some of frames that is unnecessary are can be deleted.



(Figure 5) Example of key frames extraction & editing.

Physical indexing is a temporal sequence itself of key frames. The edited key frames are manually indexed on dates, fields and subjects. This is a logical indexing.

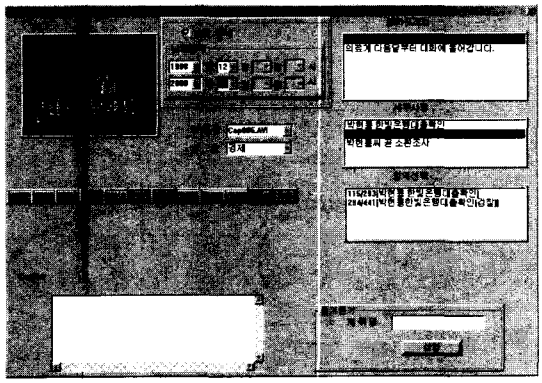
Table 1 shows the results of key frame extraction using three scene change detection methods, where TKF is a total number of extracted key frames and EKF is the number of error key frames. As showing in the results, a proposed method that combined the RGB color histogram with the x^2 (Chi Square) histogram is more efficient and optimal, since both the total number of key frames and the number of error key frames are less than other methods.

(Table 1) The results of key frame extraction

TV	Scene Detection Method	TKF	EKF
KBS	Color Histogram	46	15
	χ^2 Histogram	44	13
	A Proposed Method	38	7
MBC	Color Histogram	46	17
	χ^2 Histogram	42	13
	A Proposed Method	34	5
SBS	Color Histogram	58	25
	χ^2 Histogram	53	20
	A Proposed Method	40	7

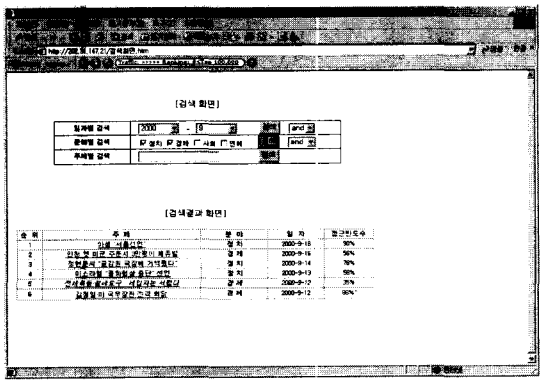
Figure 6 shows example of video retrieval. Video scene has been retrieved according to date, field and subject. The area of retrieved video scene can be increased or decreased by user's manipulation. Users can select their interested issue and play and watch the selected video scene.

A video browsing service has implemented with MySQL, PHP and JMF under Apache Web Server. We have developed the medium size of database in MySQL and the database access interface in PHP. And also, we have developed video playing service in JMF(Java Media Framework)



(Figure 6) Example of video retrieval.

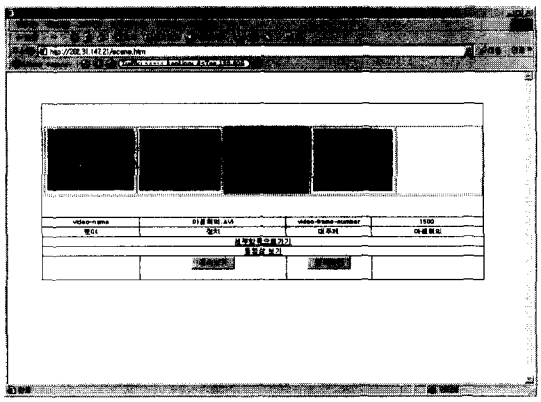
Figure 7 show video retrieval and list of retrieved video scenes on Web. Date and field are selectable and subject can be retrieved by keyword. The results of this are listed below according to the access frequency. Users can select one of listed results, and then selected item will be browsed as in Figure 8.



(Figure 7) Example of video retrieval on Web.

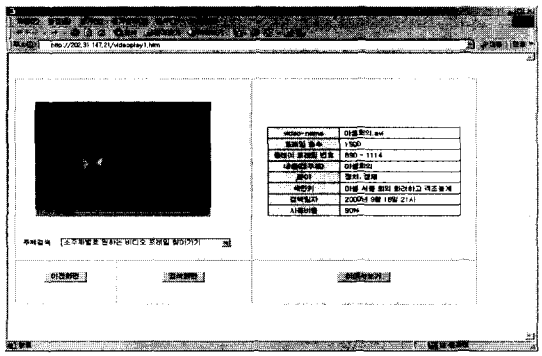
Figure 8 shows video browsing and brief information. The suitable video scenes for selected item of lists are browsed on Web. When users

select one of browsed scenes, the brief information of scene is presented.



(Figure 8) Example of video browsing on Web.

Figure 9 shows video playing and detailed information. In Figure 8, if users select the detailed item, detailed information of the scene will be presented, and if users select the video watch, video scene will be played and user can watching the video, and detailed information will be presented too.



(Figure 9) Example of video playing on Web

6. Conclusion

This paper proposed a Video Browsing Service (VBS) that provided both the video content retrieval and the video browsing by the real-time user interface on Web. We proposed a new scene change detection method that combined the RGB color histogram with the x^2(Chi Square) histogram. This new method gave better result than the result from individually using of the color histogram or the x^2 histogram.

Key frame indexing has performed by both physically and logically. Also, this system provided the function of a VCR's and the video editing services. On Web, the remote video browsing consisted of three parts; retrieval, browsing and playing of the video scenes.

In the near future, more efficient key frame extraction method based on semantic features should be developed. And semantic feature-based video retrieval and browsing framework on Web should be more enhanced than current many simple methods.

References

[1] Y. Zhuang, Y. Rui, T. S. Huang and S. Mehrotra 1998 Adaptive key frame extraction using unsupervised clustering. In Proceedings of IEEE Int'l Conference on Image Processing, Chicago, IL, pp. 886~870.

[2] Andreas Girgensohn, John S. Boreczky 2000 Time-Constrained Keyframe Selection Technique. Multimedia Tools and Applications 11(3). pp. 347~358.

[3] Smith, M. A & Kanade, T. 1995 Video Skimming for Quick Browsing based on Audio and Image Characterization. TR No. CMU-CS-95-186, School of Computer Science, Carnegie Mellon University.

[4] Zhang, H. J., Low, C. Y. & Smoliar, S. W. 1995 Video Parsing and Browsing Using

Compressed Data. Multimedia Tools and Applications 1, pp. 89~111.

[5] J. S. Boreczky and L. A. Rowe 1996 Comparison of video shot boundary detection techniques. Storage and Retrieval for Image and Video Databases (SPIE), pp. 170~179.

[6] Zhang, H. J., Kankanhalli, A. & Smoliar, S. W. 1993 Automatic partitioning of full-motion video. Multimedia Systems 1, pp. 10~28.

[7] John S. Boreczky and Lawrence A. Rowe. 1996 Comparison of video shot boundary detection techniques. In Proc. SPIE Storage and Retrieval for Image and Video Databases, pp. 170~179

[8] Zhang, H. J., Wu, J. H., Zhong, D. and Smoliar, S. W. 1997 An integrated system for content-based video retrieval and browsing. Pattern Recognition, vol. 30, no. 4, pp. 643~658.

[9] W. Wolf. 1996 Key frame selection by motion analysis. In Proc. IEEE Int. Conf. Acoust., Speech, and Signal Proc.

[10] Hampapur, A., R. Jain and T. Weymouth 1994 Digital video indexing in multimedia systems. In Proc. Of AAAI-94 Workshop on Indexing and Reuse in Multimedia systems.

[11] Hampapur, A., R. Jain and T. Weymouth 1995 Production model based digital video segmentation. Multimedia Tools and Applications, Vol. 1, No. 1, pp. 9~46

[12] E. Ardizzone, M. L. Cascia 1997 Automatic Video Database Indexing and Retrieval. Multimedia Tools and Applications, Vol. 4, No. 1, pp. 29~56.

[13] J. C. Lee, Q. Li, W. Xiong 1997 VIMS : A Video Information Management System. Multimedia Tools and Applications, Vol. 4, No. 1, pp. 7~28.

[14] B. Furht, S. W. Smoliar, H. J. Zhang 1995 Video and Image Processing in Multimedia System. Kluwer Academic Publishers, pp. 335~356.

[15] S. J. Dennis, R. Kasturi, U. Gargi, S. Antani 1995 An Evaluating of Color Histogram Based Methods in Video Indexing. Research Progress Report CSE-96-053 for the contract MDA 904-95-C 2263.

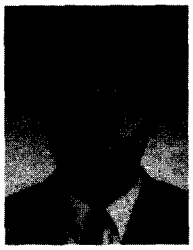
[16] Zhang, H. J., J. Y. A. Wang and Y. Altunbasak 1997 Content-based Video Retrieval and Compression : A Unified Solution. Proc. ICIP '97, Int. Conf. on Image Processing, pp. I13~16.

[17] Zhong, D. and S. F. Chang 1997 Spatio-Temporal Video Search Using the Object Based Representation. Proc. ICIP '97, Int. Conf. on Image Processing, pp. I21~24.

[18] Zabih, R., J. Miller and K. Mai 1995 Feature-based Algorithms for Detecting and Classifying Scene Breaks. Proc. ACM Int. Conf. on Multimedia, pp. 189~200.

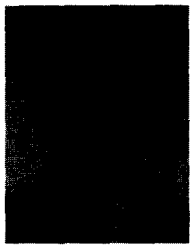
[19] Armen, F., A. Hsu and M. Y. Chiu 1993 Feature Management for Large Video Databases. In Storage and Retrieval for Image and Video Databases, Proc. SPIE, 1908, pp. 2~12.

◐ 저 자 소 개 ◑



신 성 윤

1994년 군산대학교 컴퓨터정보과학과 졸업(학사)
1997년 군산대학교 대학원 정보통신공학과 졸업(석사)
2002년 군산대학교 대학원 컴퓨터정보과학과(박사)
1998년~2002년 군장대학 컴퓨터응용학부 겸임교수
1999년~현재 : (주)네트플러스 동영상연구팀 연구원
관심분야 : 멀티미디어, 컴퓨터 비전, 인공지능
E-mail : syshin@cs.kunsan.ac.kr



이 양 원

1978년 숭실대학교 전자계산학과 졸업(학사)
1983년 연세대학교 산업대학원 전자계산학과 졸업(석사)
1994년 숭실대학교 대학원 전자계산학과 졸업(박사)
1979년~1986년 한국국방연구원 정보관리위원회 연구원
1986~현재 : 군산대학교 컴퓨터정보과학과 교수
관심분야 : 멀티미디어, 컴퓨터비전, 인공지능, 가상현실
E-mail : ywrhee@cs.kunsan.ac.kr