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자막 정보를 이용한 축구 비디오 하이라이트 생성

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Creation of Soccer Video Highlights Using Caption Information

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요 약

디지털 비디오는 대용량의 저장 공간을 필요로 하는 배우 긴 데이터이다. 따라서 비디오 시청자들은 원래의 긴 비디오를 시청하기 전에 요약된 버전을 시청하기를 원한다. 특히, 스포츠 분야에서 하이라이트 비디오는 자주 시청된다. 다시 말해서, 하이라이트 비디오는 비디오 시청자에게 그 비디오를 시청할 가치가 있는지를 결정하게 한다. 본 논문에서는 시간과 공간 형태로 된 자막의 구조적 특징을 이용하여 축구 비디오 하이라이트를 생성한다. 이와 같은 구조적 특징들은 자막 프레임 구간과 자막 키 프레임을 추출하는데 사용된다. 하이라이트 비디오는 자막 키 프레임의 장면 재설정, 논리적 색인화, 그리고 하이라이트 생성 규칙에 의하여 생성된다. 마지막으로, 하이라이트 비디오와 비디오 세그먼트들은 비디오 시청자가 브라우저를 통하여 원하는 항목을 선택함으로서 검색되고 브라우징 될 수 있다.

Abstract

A digital video is a very long data that requires large-capacity storage space. As such, prior to watching a long original video, video watchers want to watch a summarized version of the video. In the field of sports, in particular, highlights videos are frequently watched. In short, a highlights video allows a video watcher to determine whether the highlights video is well worth watching. This paper proposes a scheme for creating soccer video highlights using the structural features of captions in terms of time and space. Such structural features are used to extract caption frame intervals and caption keyframes. A highlights video is created through resetting shots for caption keyframes, by means of logical indexing, and through the use of the rule for creating highlights. Finally, highlights videos and video segments can be searched and browsed in a way that allows the video watcher to select his/her desired items from the browser.

▸ Keyword : 하이라이트 비디오(Highlight Video), 장면전환검출(Scene Change Detection), 자막 프레임 구간(Caption Frame Interval), 자막 키 프레임(Caption Key Frame).

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Ⅰ. Introduction

In a video database, video contents are described as the shot or scene structure[1]. A shot is a valid unit forming video information, that consists of one or more sets of successive frames, and that represents continuous motions at some point in time and space. Currently, wide attention among researchers is being paid to automated/semi-automated schemes for video shot detection and characterization.

Video indexing can be performed efficiently by means of caption text extraction and recognition. This has led to some remarkable progress, for example, in enabling the automatic conversion of hard-copy documents using optical character recognition(OCR) technology[2,3,4,5], and in simulating languages using voice recognition(VR) technology[6,7]. In both cases, as exemplified above, outputs are created in ASCII text format for which indexing can be performed by conventional, not-so-perfect information retrieval techniques. From this, we can see that video sources containing a mine of information(i.e., news, ads, movies, and sports events)contain important contents in the form of voice, caption texts, and/or texts in images.

A video summary helps the user who desires to watch a particular video determine whether it is well worth watching. The video summary is classified into two types: video summary sequence and highlights video. A video summary sequence is suited to documentaries given that it provides an important overview of the whole original video. On the contrary, a highlights video highlight is suitable for video previews or sports highlights because it only contains video segments worthy of interest[8].

In this paper, we propose a scheme for generating soccer video highlights, using the structural features of captions in which appearance features in terms of time, as well as features such as spatial locations, areas, and colors are used. Such structural features of captions are used to extract caption frame blocks and caption keyframes from input frames. The caption keyframes are indexed both physically and logically. Soccer video highlights are created through a predefined rule for creating highlights. In addition, efficient retrieval and browsing techniques are provided as a means of allowing for selecting and watching videos in a fast and convenient manner.

This paper consists of the following sections. Relevant researches are described in Section 2, and structural features of captions in Section 3, extraction of caption frame intervals and caption keyframes in Section 4, creation of soccer video highlights in Section 5, experiment results in Section 6, and finally, thesis conclusions in Section 7.

Ⅱ. Relevant Researches

Studies on the field of video summarization have been continuously conducted by a number of researchers. A video summary is classified into two types: video summary sequence and video highlight. Schemes for creating video summary sequences include video skimming[9], shot change graph[10], cluster validity analysis[11], and video manga[12]. In addition, schemes for video highlights include movie trailer[13,14] and event-based sports summarization[15].

Christal et al.[9] proposed video skimming enabling the summarization of documentaries or news broadcasts. In this scheme, videos and their copies are assigned in order of words used, and important words in the copies are identified through language analysis. As a result, video clips are selected in order of the prioritized words. Yeung et al.[10]

proposed the shot-based change graph featuring the use of story streams. Hanjalic et al.[11] extracted keyframes and set video shots, and then created video summary sequences containing the keyframes through the use of cluster validity analysis. Uchihashi et al.[12] proposed video Manga featuring comic cartoon styles as a scheme for generating video summaries. They used video Manga to measure importance based on the scarcity and persistency of video segments.

Another type of video summarization is highlights extraction. Lienhart et al.[13] and Pfeiffer et al.[14] proposed a scheme for automatically creating movie trailers by searching low-level visual/audio features, motion information, and color information. In this paper, the empirical features of the basic physical parameters for digital videos were used as a means of selecting important objects, persons, actions, dialogues, title texts, and title music clips. Babaguchi et al.[15] proposed a sports video summarization scheme using event-based video indexing. Despite its usefulness in the summarization of videos, this scheme loses a considerable number of important features that represent meanings.

III. Structural Features of Captions

3.1 Caption Region Analysis

Captions appearing in a soccer video are an important element that allows the user to see how the soccer game develops. The caption region of a soccer video differs in the following features from that of a drama or documentary:

1) Position: The positions of different caption regions are fixed by shape.
2) Area: Each caption region has its own area.
3) Existence: (Once an event occurs), every caption region immediately appears, exists for a while, and disappears.
4) Change: The position of texts changing within a caption region is fixed.
5) Color: Each caption region has its own color.
6) Pont in Time of Appearance: The caption region of an event appears directly following occurrence of the event.
7) Order of Appearance: The order of appearance of a caption can differ depending on each individual game.

Based on the caption features described above, caption keyframes are extracted and video segments are indexed. This process plays an important role in creating soccer video highlights.

3.2 Caption Scene Analysis

In a soccer video, a limited number of captions occur. In this paper, captions are divided by semantics of video contents into:

1) Team(Ctem): Both team names(Each regional/ team name)
2) Stadium(Cplc):Stadium name(Stadium and its region)
3) Broadcast Booth(Cbct): Sportscaster names (Announcer and commentator)
4) Referee(Cref): Referee names(Chief referee and sub referee)
5) Player List(Clst): Player list of both teams;
6) Game Begin(Cbgn): Beginning of the game (First/second half of the game and team names)
7) Scoreboard(Csco): Game scores(First /second half of the game, time frame, team names, and scores)
8) Bench(Cbch): Benches for both teams(Head coach/assistant coach/bench player names)
9) Player(Cplr): Names of players who had shoots, assists and free kicks, and who committed general fouls;
10) Player exchange(Cchg): Names of players who are exchanged
11) Goal(Cgol): Names of players who scored goals;

12) Foul(Cfol): Names of players who were given red cards such as warning or exit for committing critical fouls;
13) Game End(Cend): Termination of the game (Names of and scores of both teams).

In addition to the caption shots described above, captions with little relevance to the current game (i.e., sports, game type, tournament, team ranking, weather, other stadiums, and records) occur in a soccer video. In this thesis, no consideration was given to the categorization and extraction of such additional captions.

3.3 Caption Features in Terms of Time

As shown in 〈Table 1〉, captions are classified by the order of appearance into start caption, event caption, and end caption. In general, those captions have some structures in terms of time as shown in (Fig. 1).

표 1. 시간에 따른 자막의 분류
Table 1. Categorization of Captions in Terms of Time.

Categorization as a Function of Time	Caption Configuration
Start Caption	Ctem, Cplc, Cbct, Cref, Clst, Cbgn
Event Caption	Csco, Cbch, Cplr, Cchg, Cgol, Cfol
End Caption	Cend

Before the game starts in earnest, captions appear in order of Ctem, Cplc, Cbct, Cref, Clst, and Cbgn. In some situations, the order of appearance of such captions varies slightly according to games. As the game starts in earnest, event captions appear. When the game ends, the end caption Cend appears.

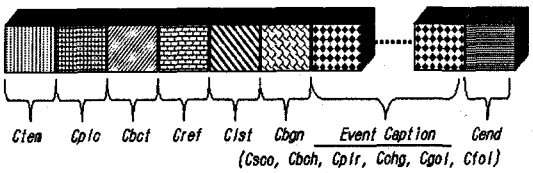

그림 1. 자막의 시간적 흐름
Fig 1. Flow of Captions as a Function of Time

As illustrated in (Fig 1), event captions representing events include Csco, Cbch, Cplr, Cchg, Cgol, and Cfol. There are some differences in the order of appearance of the event captions. Some event captions appear directly following occurrence of a particular event while the soccer game goes on. The caption Cend indicating the termination of the game displays the result of the game.

〈Table 2〉 shows the appearance features of captions.

표 2. 자막의 등장 특성
Table 2. Appearance Features of Captions.

Captions	Caption Configuration	Appearance Features
Start Captions	Ctem, Cplc, Cbct, Cref, Clst, Cbgn	- Convey an overview of the game; - Appear independently.
Event Captions	Csco	- Appear in a short-/long-term manner throughout the soccer game; - Appear at any time; - Appear independently or in an overlapping manner with other captions.
	Cbch, Cplr, Cchg, Cgol, Cfol	- Appear directly following occurrence of an event; - Appear independently of Csco.
End Captions	Cend	- Conveys the result of the game; - Broadcast terminated.

3.4 Caption Features in Terms of Space

The spatial caption structure is the information of the position region in a soccer video where captions appear. As illustrated in (Fig 2), the captions appear in a limited number of regions 6.

As shown in (Fig 2), the caption regions such as Csco, Clst, Cbgn, Cend, and Cref overlap with each other. However, they have their own area. The captions such as Ctem, Cplc, Cbct, Cbch, Cplr, Cgol, Cfol, and Cchg differ in size little from each other, and appear in the middle of the lower part of the frame.

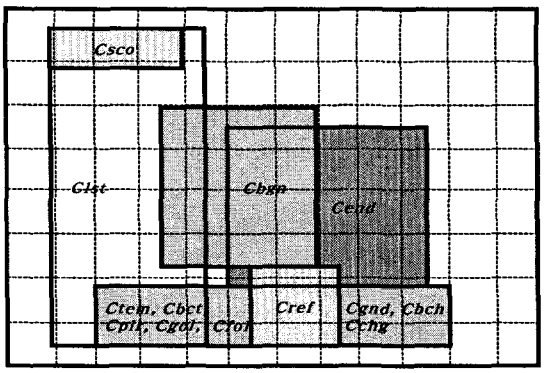

그림 2. 자막의 공간적 구조
Fig 2. The Structure of Captions in Terms of Space.

In this thesis, caption keyframes are extracted from 13 caption scenes, based on the features of caption regions. The keyframes are indexed to search video segments for different subjects. Therefore, the extraction and indexing of caption regions plays an important role in developing a soccer video database.

IV. Extraction of Caption Frame Intervals and Keyframes

4.1 Extraction of Caption Frame Intervals

Every caption in a soccer video has its own position, area, and color value. Based on such features, caption frame intervals are extracted by means of similarity measurement.

Caption frame intervals are extracted by performing a comparison between the structural features predefined for caption positions, areas and colors, and the features of input frames. If any similarity between those features exists, the input frames become caption frame candidates. Such similarity measurement is continuously performed across the whole frame. The successive frames meeting similarity requirements are specified as caption frame blocks. The method for similarity measurement is addressed as follows:

4.1.1 Similarity Measurement of Caption Positions

$$|x_{f_i} - x_t| < T_x \quad AND \quad |y_{f_i} - y_t| < T_y \quad \cdots\cdots (1)$$

In Equation (1), xfi and yfi are coordinate values for input frames; xt and yt are reference values obtained by means of structural features; and Tx and Ty are critical values for positions.

4.1.2 Similarity Measurement of Caption Areas

$$\frac{A_{m_i}}{A_{f_i}} > T_A \quad AND \quad \frac{A_{m_i}}{A_t} > T_A$$

where

$$A_{m_i} = (\max(x_{f_i}, x_t), \max(y_{f_i}, y_t), \min(x_{f_i}, x_t), \min(y_{f_i}, y_t)) \quad (2)$$

In Equation (2), Ami refers to the area of the caption region overlapping between input frames and reference frames. Afi and At refer to the area of caption regions for input frames and the area of caption regions for reference frames, respectively. In addition, TA refers to the critical value for areas.

4.1.3 Similarity Measurement of Caption Colors

$$C_{f_i}^{R} - C_t^{R} < T_C \quad AND$$
$$C_{f_i}^{G} - C_t^{G} < T_C \quad AND$$
$$C_f^{B} - C_t^{B} < T_C \qquad \cdots\cdots (3)$$

In Equation (3), $C_{f_i}^{RGB}$ and C_t^{RGB} refer to the maximum number of RGB pixels in the caption region for input frames and the maximum number of RGB pixels in the caption region for reference frames, respectively. TC refers to the critical value for colors.

4.2 Extraction of Caption Keyframes

Caption frame blocks extracted indicate important events. However, all frames aren't necessarily keyframes. As such, one typical frame representing the whole caption frame block becomes the caption keyframe.

As illustrated in (Fig. 3), the first of the caption frame blocks becomes the keyframe. The caption keyframe plays an important role in performing video retrieval and browsing, and in creating highlights.

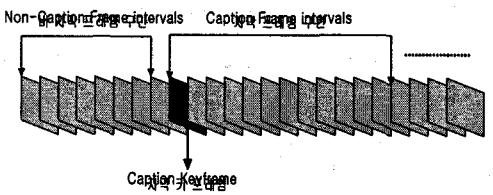

그림 3. 자막 키 프레임 추출
Fig 3. Caption Keyframe Extraction.

V. Highlight Creation

5.1 Scene Reset

5.1.1 Necessity of Resetting Scenes

Event captions like Cplr, Cchg, Cgol, and Cflt appear directly following occurrence of an event. Therefore, real events exist in the preceding segments of the caption keyframe. Scene reset refers to the process of resetting event scenes in such a way as to allow scenes to have real events.

In the soccer video, event captions appear immediately following occurrence of an event, with the exception of the start/end captions and intermittent captions appearing on the scoreboard. As described in 〈Table 3〉, scene reset is implemented for the scenes that need to be reset.

표 3. 장면 재설정 구분
Table 3. Scene Reset Category

Category	Relevant Scenes
Scenes that need no resetting	*Ctem, Cplc, Cbct, Cref, Clst, Cbgn, Csco, Cbch, Cend*
Scenes that need to be reset	*Cplr, Cchg, Cgol, Cfol*

In 〈Table 3〉, the scenes that need no resetting are left intact with no scene reset.

5.1.2 Scene Reset Technique

The scenes that need to be rest must include caption frame intervals and preceding events. (Fig 4) shows how to reset the scenes that need to be reset. The caption frame intervals include all frames containing their captions. The number of preceding events should ample enough to represent important events.

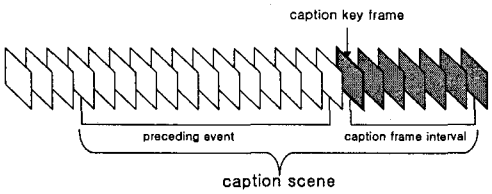

그림 4. 장면 재설정
Fig 4. Scene Reset.

Generally, the amount of time required to represent the preceding event is between 10 seconds and 20 seconds. Hence, in this paper, we set the amount of time required for the preceding event at 20 seconds. Accordingly, the preceding event has a total 600 frames based on the standard 30 frames per second. As s result, a caption scene comprises a preceding event(600 frames/20 seconds) and a caption frame interval.

5.2 Highlight Creation

Prior to creating highlights, the number of highlight-based scenes must be determined. The most important event in the soccer video is a goal. Therefore, the number of highlight-based scenes needs to be determined in a flexible manner with the number of goals taken into account. (Fig 5) shows a flow diagram of highlight generation and the rule for creating highlights is described below:

1) A highlight consists of the following scenes: Ctem, Cgnd, Cbct, Cref, Clst, Cbgn, Cplr, Cchg, Cgol, Cfol, and Cend. The more detailed rule for creating highlights is as follows:

A) Start Scene
(1) The initial scene consists of Ctem.
(2) The next scene consists of Cgnd-Cbct or Cbct -Cgnd in order of the original video.
(3) The next scene consists of Cref-Clst or Clst -Cref in order of the original video.
(4) The final scene consists of Cbgn.

B) End Scene
(1) The end scene consists of Cend.

C) Event Scene
Event scenes are included in the highlight in order of prioritized next events. The process of comparing between the total number of highlight scenes created for each step and the number of highlight-based scenes is implemented until the two values are equal or the final event is included in the highlight.
(1) The initially appearing event consists of Cgols in order of the original video.
(2) The second event consists of Cplrs in order of the original video.
(3) The third event consists of Cfols in order of the original video.
(4) The finally appearing event consists of Cchgs in order of the original video.

2) If the total number of highlight scenes created so far is less than that of reference scenes, the final highlight video becomes the current highlight.

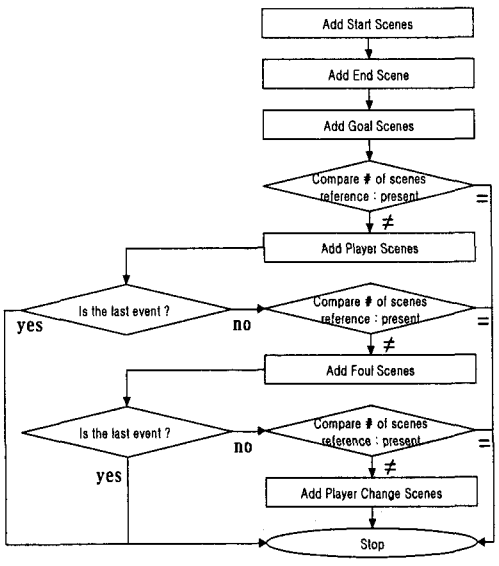

그림 5. 하이라이트 생성 흐름도
Fig 5. A Flow Diagram of Highlight Generation.

During the 2004 Korean professional football league (K-League), an average of zero-to-six goals were scored per game. In that case, a highlight has 0 or up to 6 goals. Other scenes are included in the highlight according to the rule for creating highlights.

5.3 Retrieval and Browsing

An indexed video and a highlights video need to be browsed by the user who wants to search video segments. As shown in (Fig 6), the video browser has retrieval and VCR functions.

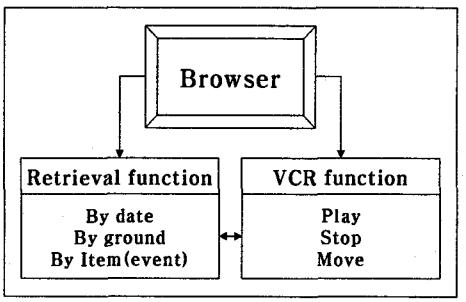

그림 6. 브라우저의 기능
Fig. 6 Browser Functions.

It is desirable that the user should implement the search function. As shown in (Fig 6), the user can select the date, stadium, and event to search his/her desired video segments. Search results are then displayed on the screen. In addition, the VCR function enables selected video segments to be played, stopped and moved.

VI. Highlight Creation

For the purpose of this paper, we used Visual C++ 6.0 in Pentium 1.3Ghz and Windows 2000 Server environments. From the first halves of the four games of K-League football club, experimental video data were obtained using a standardized AVI file format of 320 X 240.

(Fig 7) shows the process of extracting caption keyframes through extracting caption regions and caption frame intervals. The image on the left side in the figure shows the video selected is being played. The segmented images on the right side show extracted caption keyframes. On the bottom are operation buttons that allow for selecting, playing and pausing video segments.

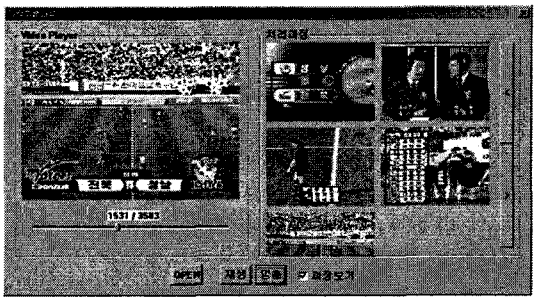

그림 7. 자막 키 프레임 추출 과정의 화면
Fig 7. The Screen Showing a Caption Keyframe Extraction Process.

Extracted caption keyframes are important elements for creating soccer video highlights. 〈Table 4〉 shows the result of extracting caption keyframes.

표 4. 자막 키 프레임 추출 결과
Table 4 The Result of Extracting Caption Keyframes.

Games	Number of Caption Keyframes
Video A	62
Video B	54
Video C	67
Video D	58

(Fig 8) shows the process of creating highlights in the soccer video according to the rule for creating highlights. On the upper part of the screen are a video player, simple operational buttons and a frame indicator. On the lower part of the screen are caption keyframes included in the highlight.

The number of highlight-based scenes was set at 20 for creating highlights. Accordingly, one highlights video consists of 20caption scenes. The average amount of time for an input video to be played is 58.3minutes, and the average amount of time for a highlights video to be played is 6.7 minutes. Therefore, a video watcher can understand the whole contents of a video within 6.7 minutes by watching a highlighted version of the video.

그림 8. 하이라이트 생성의 화면
Fig 8. The Screen Showing a Highlight Creation Process.

If a video watcher selects his/her desired date or duration, a list of events satisfying such conditions appear. At that time, the video watcher can select his/her desired event, and narrow his/her search further. In addition, when a list of keyframes for selected events appears, the video watcher can select a keyframe to watch a selected shot. (Fig 9) shows video browser.

그림 9. 비디오 브라우저
Fig 9. Video Browser.

〈Table 5〉 shows a comparison between the proposed scheme and existing video summarization schemes. Through the use of the structural features of captions, the

표 5. 비디오 요약 방법들의 비교
Table 5. Comparison among Video Summarization Schemes.

Schemes		Features	Strengths	Problems(Difficulties)
Summarization Sequence	Video Skimming	-Color/captions -Audio keywords -Keyword frequency	-Event indexing	-Language analysis -Object/caption recognition
	Scene Change Graph	-Story streams -Time windows	-Simple and fast	-Setting time windows -Overlapping stories
	Cluster Validity Analysis	-Clustering -Cluster distance	-Diverse structuring	-Cluster configuration -Criteria for validity
	Video Manga	-Comic cartoon style -Segment scarcity -Segment persistency	-Effective in cartooning	-High overhead costs -Setting a matching criteria -Lack of accurateness in the extraction of keyframes
Highlights	Movie Trailer	-Low-level physical features -Empirical parameters	-Ease in the extraction of features -Various parameters	-Experience accumulation and its application -Semantic matching -Changes in experience
	Event-based Sports Highlights	-Event-based indexing -Closed captions -Time windows	-Definition and description of events	-Event extraction -Difference in point in time
Proposed Scheme		-Event-based/ caption-based -Structural features (in terms of time and space) -Rules for creating highlights	-Definition and description of events -Priority placed on events -Logical indexing	-Limited domain -Caption focus

proposed scheme creates highlights in a more efficient manner than other schemes do.

Ⅶ. Conclusions

In this paper, we proposed a scheme for creating soccer video highlights in an efficient manner through the use of the structural features of captions in terms of time and space. The structural features of captions were extracted by performing an analysis of caption information, and caption frame intervals and caption keyframes extracted through the use of those features. Also, we used an efficient rule for creating highlights so that video watchers can their desired video in a fast and convenient manner. As a result of performing experiments, it was observed that while the average amount of time for an input video to be played was 58.3minutes, the average amount of time for a highlights video to be played was 6.7 minutes. This allows video watchers to understand the whole contents of an original video within 6.7 minutes, thereby enabling the video watchers to determine whether the original video is worth watching. In addition, the proposed scheme allows for selecting from a diverse range of videos, as well as enabling reduction in time and costs. The video browser described in this paper has been designed for efficient and fast retrieval. This paper provides

a basis for the implementation of enhanced sports video management systems.

It is believed that future research needs to be focused on enabling automatic extraction of active captions and on extracting semantic-based events. Also, an automatic indexing of video segments is considered to be achieved.

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