A Novel Method for Extracting Dynamic Character Network from Movie

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Abstract. In this decade, the number of movies is increasing rapidly. Many studies have been proposed to assist users in movie understanding. In which, these methods are taken into account movie content analysis using social network for discovering relationships among characters and so on. However, these methods have shown some unsatisfactorily in dynamic changing of multimedia contents such as the character's relationships over time. For overcoming this issue, we proposed a novel method for extracting dynamic character network from a movie.

Keywords: Dynamic social network · Storytelling analysis · Multimedia analysis

1 Introduction

Today, the number of movies is increasing rapidly. The demand of an effective method for discovering useful information and the story of movie is raising and becoming a challenge task. Various methods and techniques have been proposed for overcoming these issues, in which social network analysis is one of efficient technique for analyzing the storytelling of a movie. In this regards, the story of a movie could be design as a network with a node represents a character and edges represent relationships among characters. The strength of a relationship shows to audiences how a relationship important is. Study from Park et al. showed that we can extract a character network from their's dialogs, and roles of characters are determined based on character network analysis [1]. Moreover, Weng et al. proposed a method for extracting a character network based on the character occurrences [6]. However, such methods have not considered to dynamic changing of character network over time.

Recent years, social network analysis has become a most popular method for discovering useful information from a movie. While using social network for analyzing a movie, an object is represented by a node and edges represent the relationships among them. Regarding this issue, many approaches have been proposed to analyze the content using character network analysis which is extracted

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from a movie. However, these methods are focused on static social network only [1,6]. In general, a static network is represented as a graph with nodes and edges. This network do not deal with time dimension - one of important factors. In order to address this issue, some approaches have been proposed for analyzing the content of a multimedia document using dynamic social network analysis [2,3]. Exploring movie content is also challenge task. Recent research are focused on extracting a character network based on character's occurrences and co-occurrences. By analyzing this network, the role of characters is discovered as our previous work [4,5]. However, such methods are not considered to timing characteristics of character network, which will show some effective information from movie. This study takes into account proposing a novel method to extract dynamic character network based on character's occurrences and co-occurrences of a movie for overcoming this issue.

This paper is organized as follows. Section 2 discusses a novel method and an algorithm for extracting dynamic character network from a movie. Section 3 describes results and discussion of proposed method. Conclusion and future work of this study are described in Sect. 4.

2 Dynamic Character Network

Movie has a set of characters. These characters play an important role for narrating story based on character's interaction and their occurrences. In general, a character network from the movie is described by a set of nodes and edges where a node represents a character and edges represent the relationships among them. So that, this study takes into account these features for extracting dynamic character network from a given movie.

Regarding the extraction of dynamic network, we applied our previous work for representing the occurrences of characters during movie playback. In this regards, the occurrences of characters are timing characteristics and represent as a set of occurrences sequences, which contain start and end of occurrence time. The sequences of the occurrences of a character is described as the following. Let $\mathcal{C}$ be the set of character in a movie.

Definition 1 (Occurrence Sequence). *The occurrence sequence of a character is defined as the following.*

$$\mathcal{S}_{c_i} = \left\langle \left[t^s_{1_i}, t^e_{1_i}\right], \left[t^s_{2_i}, t^e_{2_i}\right], .., \left[t^s_{k_i}, t^e_{k_i}\right] \right\rangle \tag{1}$$

where $t^s_{k_i}$ and $t^e_{k_i}$ is the starting and ending time of character c_i who occurs in a movie playback, c_i is a character in $\mathcal{C}$, $i = [1..N_C]$, $k \in N$.

Let c_i and c_j are two characters in a movie. $\mathcal{S}_{c_i}$ and $\mathcal{S}_{c_j}$ are two occurrence sequences of c_i and c_j. We compute the co-occurrences sequence of two characters c_i and c_j as the following.

Definition 2 (Co-Occurrence Sequence). *The co-occurrence sequence of character c_i and character c_j is defined as the following.*

$$\mathcal{A}_(c_i, c_j) = \left\langle S_{c_i} \cap S_{c_i} \right\rangle \tag{2}$$

Let $\mathcal{A}_{(c_i,c_j)}$ is the set of co-occurrence sequence of characters c_i and c_j in a movie. We compute total length of character c_i co-occurs to character c_j as the following.

$$l(\mathcal{A}_(c_i, c_j)) = \sum_{a_i \in \mathcal{A}_(c_i,c_j)} (a_i) \tag{3}$$

Besides, $n(\mathcal{A}_{(c_i,c_j)})$ is the number of co-occurrences between character c_i and c_j.

Regarding dynamic character network analysis, we compute the total of time that characters co-occur and the number of time that them occur at each time t during the playback of a movie.

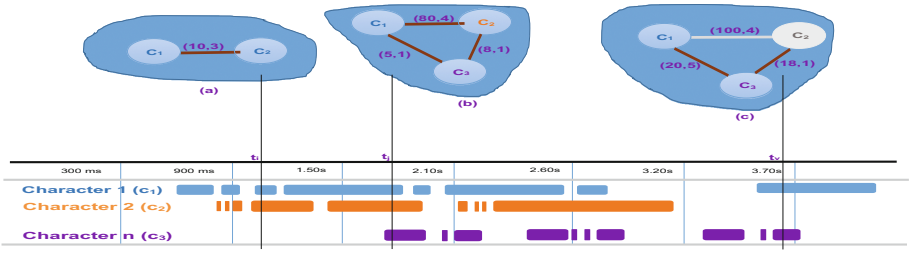

Fig. 1. Dynamic Character Network construction. (a) Character Network at the time t_i; (b) Character Network at the time t_j; (c) Character Network at the time t_v.

In our previous study, we defined CoCharNet as a set of nodes and edges as the following [4]. In which character's occurrences are indexed by "on-screen" visually methods.

Definition 3 (CoCharNet). *CoCharNet is described by a undirected-weight graph as the following*

$$G = \langle C, E \rangle$$

where $C = \{c_1, c_2, ..., c_k\}$ is the set of characters, and E is the set of relationships among them in a movie, in which E is calculated as follows.

$$E = \left\langle (c_i, c_j, l(A_(c_i, c_j)), n(A_{c_i,c_j}) \right\rangle \tag{4}$$

where means character c_i has a relationship with character c_j by total time of co-occurrences $l(A_(c_i, c_j))$ and number of co-occurrences $n(A_{c_i,c_j})$.

Dynamic character network is undirected weighted graph that the topology of this network are changed over time, we define dynamic character network by applying the timing characteristics of the occurrences as the following.

Definition 4 (Dynamic Character Network). *Let L is total length of a movie. Dynamic character network from a movie is described by a sequence of undirected graph as the following.* $\mathcal{D} = \left\langle G_1, G_2, ..., G_L \right\rangle$

where $G_t = \langle C_t, E_t \rangle$ is a undirected weighted graph of character at the time t, C_t is the set of characters at the time t, $0 < t < L$, E_t is the set of relationships among characters in C_t at the time t as follows. The set of relationships among characters C_t is described as the following.

$$E = \left\langle (c_i, c_j, l(A_(c_i, c_j))_t, n(A_{c_i,c_j})_t \right\rangle \tag{5}$$

where means character c_i has a relationship with character c_j by total time of co-occurrence $l(A_{c_i,c_j})_t$ and number of co-occurrence $n(A_{c_i,c_j})_t$ at the time t.

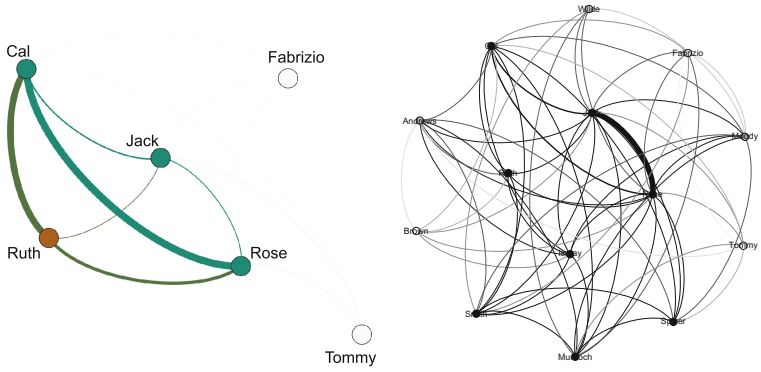

Fig. 2. Dynamic Character Network from Titanic (1997) Movie. (a) t = 30 min; t = 3 h and 10 min.

Figure 1 illustrates the construction of the dynamic character network which is extracted from the given movie. In this regards, at the time t_i, characters c_1 and c_2 are set as active and relationships among them will be calculated. This process is same at the time t_j and t_v, characters c_1 and c_2 and c_3 are set as active depend on their occurrence and co-occurrence. In this regards, relationships among characters will be recalculated at the certain time t.

In order to extract dynamic social network from a movie. Algorithm for extracting dynamic character network is described as the following.

Algorithm 1 illustrates the proposed method for extracting a dynamic character network based on the occurrences and co-occurrences of characters in the given movie.

Algorithm 1. Extracting Dynamic CoCharNet

INPUT $\mathcal{A}_\mathcal{C}$ is the set of character occurrence intervals;
OUTPUT Dynamic CoCharNet $\mathcal{D}$;
procedure DYNAMIC_COCHARNET($\mathcal{D}$)
  for e **do**ach time t
    while (existing a_i in $\mathcal{A}_\mathcal{C}$) and ($[t_k^{start}, t] \subseteq \mathcal{A}_\mathcal{C}$) **do**
      compute $l(\mathcal{A}_\mathcal{C})$;
      compute $n_{\mathcal{A}_\mathcal{C}}$;
      create nodes appeared in a_i;
      create an edge in $\mathcal{G}_t$ *with total time of characters co-occurrence* $l(\mathcal{A}_\mathcal{C})$ *and number of co-occurrence* $n(A_{c_i,c_j})$ *at time* t;
      $\mathcal{D} = \mathcal{D} + \mathcal{G}_t$
    end while;
  end for;
  return Dynamic CoCharNet $\mathcal{D}$;
end procedure

3 Results and Discussion

Difference to static network, dynamic network uses node movements or endogenous process over time in the underlying network structure. Figure 2 illustrates the construction of character network from Titanic (1997) movie. At the beginning, *Cal (Caledon Hockley), Ruth (Ruth DeWitt Bukater) and Rose (Rose DeWitt Bukater)* are the main characters and they play an important role. But at the end, *Rose (Rose DeWitt Bukater) and Jack (Jack Downson)* are the characters that play important role of the movie. Characters and relationships among them in dynamic character network are changed over time.

In order to help the audiences in movie understanding, dynamic social network analysis is a good way for understanding movies content. By using this network, we can understand how do relationships among characters start and grow during movie playback. Character's occurrences and co-occurrences are able to use for extracting a dynamic character network but other features including character's emotions, activities, and so on should be considered for getting more performance. Next period can be achieved by using this features.

4 Conclusion

Social network analysis has become an important way for analyzing movies content. Many studies have been proposed for extracting social network and analyzing it to discover hidden information from them. However, these methods have considered in static character network for analyzing movie storytelling. In this study, we have proposed a method for extracting dynamic character network based on the occurrences and co-occurrences of characters in a movie. Based on this network, how are relationships among character changing overtime will be described.

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