Journal of Universal Computer Science, vol. 21, no. 6 (2015), 796-815
submitted: 13/11/14, accepted: 20/2/14, appeared: 1/6/15 © J.UCS

CoCharNet: Extracting Social Networks using Character Co-occurrence in Movies

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Abstract: Discovering content and stories in movies is one of the most important concepts in research studies. To consider how to efficiently determine the relationships between characters, we focus on the appearance of each character during movie play and analyze the characters' relationships to build a CoCharNet, a social network, to determine characters' relationships in a movie. In this paper, we propose an innovative method which extracts and analyzes characters' relationships based on social network measurement and evaluation.

Key Words: CoCharNet; Character identification; Social network; Movie analysis.
Category: H.1.1, H.3.5, I.2.11

1 Introduction

Recently, the number of movies produced annually has increased significantly. Understanding the message behind movies has become complex and challenging. Hence, determining the content and stories in movies has become an important research fields in computer science. Many technologies and approaches have been proposed to determine the content and stories in movies. Any particular movie has its own hierarchy and tells stories under the director's ideas. The story of the movie usually suggests some of the main areas of the movie theory, where some central concepts immediately portray useful information. In drama theory, the concepts of the movie are presented, which reveal the practical side of the theory and provide a solid foundation for more in-depth exploration to come.

When an audience watches a movie, they usually compare the characters and the relationships between them. Archetypal characterization is a form of storytelling shorthand. Characters in a movie are known as "Main Character(s)" or "Protagonist(s)", the heroes or chief proponents and principal drivers, the main purpose of which is to achieve the story's goal. "Antagonists" are characters

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who oppose the hero and try to stop the mission of the hero. "Rational" characters are calm, cold and collected, while "Emotional" characters are frenetic, disorganized, and driven by feeling. "Sidekicks" are characters who support the protagonist and "Skeptics" are characters who oppose the Sidekicks. "Guardian" characters strongly support the protagonist and "Contagonists" are characters who oppose the Guardian [Phillips and Huntley 2001]. Most movies normally contain all types of characters and the problem becomes determining who belongs to each group.

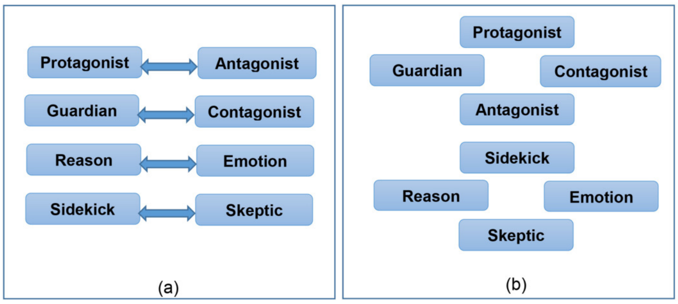

Figure 1: The relationship of characters in the movie theory. (a) the relationships between archetype characters, and (b) the driver quad of archetype characters

It is very easy to analyze the main character (known as the "protagonist" or "hero"). A main character is the player who allows the audience to experience the story of the movie first hand, while the minor characters, who support the main character, tell the story line. Extracting characters to analyze relationships between them is a method used to retrieve useful information about the movie. Fig. 1 illustrates the relationships between characters in a movie and their roles in the story. Identifying these relationships is the most important work in movie analysis.

So far, many studies have been proposed to analyze the movies. These approaches are based on recommendation systems [Jung 2012, Jung 2014] and social network analysis [Park et al. 2012, Jung et al. 2013, Weng et al. 2009]. From scrutinizing to movie analysis, we can start by discovering the content or abstract of the movie to understand its concept. Many approaches have been proposed to retrieve useful information about the movie and numerous systems have been implemented such as text/script mining, image processing, and video clustering and segmentation [Adams et al. 2002, Rasheed et al. 2005]. In content-based concepts, information is extracted and retrieved based on three low-level features: visual, audio, and textual features. These techniques are used to extract and retrieve information using several schemes, e.g., visual-based, audio-based, and text- or hybrid-based. However, these techniques are mainly based on feature detection and recognition approaches [Fabro and Böszörmenyi 2013]. Content-based techniques are usually used to detect and recognize objects or features in a movie or video.

Recently, the story-based approach has been introduced as a new form of analysis of knowledge in a movie, especially in considering a character's story and retrieving information from them. The relationships between characters and scenes and between characters are extracted and discovered to understand the movie. Social network analysis can also be applied to measure and discover the story in the movie. Social network theory has been widely applied to many research areas such as recommendation system [Jung 2012], video segmentation and discovering [Ding and Yilmaz 2010], movie analysis [Rasheed et al. 2005], and characters and relationships among characters analysis [Weng et al. 2009, Park et al. 2012].

In drama or movie theory [Phillips and Huntley 2001], the characters have an important role. The relationships between the characters and the appearance of the characters tell the story of the movie. In this research, we propose a method to extract the social network by considering the appearance of the characters in the movie. The proposed method provides the concept for analysis and retrieval of useful information in the movie such as the appearance of the characters, relationships between characters, strength of the relationships between characters, characters' classification, and the importance of the characters in the movie using social network analysis and evaluation. Our proposed method, CoCharNet, uses the appearance and co-occurrence of the characters in the movie to extract the social network. Based on the appearance of the characters and relationships between them, we classify the importance of characters into certain classes to understand the movie. CoCharNet is a method based on story-based analysis and uses social network analysis and evaluation to retrieve useful information in the movie. Our objective is to develop a system that can evaluate the importance of a character in the movie. The contributions of our research are as follows:

- Extracting the social network (called CoCharNet) based on the co-occurrence of the characters and relationships between them
- Classifying the characters to evaluate the importance of characters in the movie by using CoCharNet

The paper is organized as follows. Recent research and related works will be described in the Sect. 2. The main definitions and methods for constructing CoCharNet will be described in Sect. 3. The evaluation and discussion of the proposed method will be described in Sect. 4. Finally, in Sect. 5, the conclusion of this work is given and future works will be described.

2 Related work

As previously mentioned, the movie research field is complex and challenging. Many concepts and approaches have been used to discover and retrieve useful information in a movie. Traditional approaches have used object recognition, known as the content-based method. These approaches are based on low-level features: visual features, audio features, and textual features. The features can be extracted and analyzed by segmentation. Various studies have also been based on scenes segmentation and scenes detection methods. Almost all scenes segmentation approaches start by detecting features in the frame at the initial stage. A shot within the movie may contain some useful information needed. A method has been attempted that surveys the key-frame extraction algorithms in detection [Truong and Venkatesh 2007]. Video segmentation is another approach that only considers the visual features that are usually used in the movie.

RoleNet [Weng et al. 2009] is a method used to determine the roles in the movies. This method uses a face recognition strategy to detect the co-occurrence of the characters on the scenes. If two characters co-occur in the scenes, a relationship between them is created and the weight of this relationship is measured. Social network analysis technology is used to analyze and discover the story of characters in the movie. RoleNet automatically classifies major roles and supporting roles, and identifies the characters belonging to these roles. RoleNet produces a weighted graph with the nodes illustrating the character in the movie, the edges indicating the relationships between characters, and the weights are given by the number of characters' co-occurrence in the frames. [Park et al. 2012] proposed Character-net, an approach to extract social networks by considering the dialog between characters in the movie. Dialog in the movie contains time, a speaker, and a listener. These features can be extracted from the subtitles and the speaker of the characters by text mining and speech recognition. Character-net automatically classifies characters into several roles: major roles, minor roles, and extra roles. Character-net produces a graph with the nodes representing characters and the edges representing the relationships between characters and the weights, and the directions illustrate the direction of the dialog in the movie.

The purpose of this work is to utilize movie analysis and social network analysis, which are associated research fields in social science [Jung et al. 2013]. In social science, interactions between elements and their relationships are modeled as a complex network, and the techniques are designed to discover and understand the hidden knowledge of social networks that are not directly perceived or measured (e.g., [Jung et al. 2013, Weng et al. 2009]). In this paper, we extract social networks from the movie using character annotation and the computational strength of the relationships between characters to discover hidden knowledge in movies. We attempt to extract social networks, and identify characters in the movie using social science analysis and social network evaluation strategy. By discovering information about characters in a movie, we can describe the basic concept of social networks based on character annotation; the methodology involves building social networks from the characters and determining the main characters and their relationships.

3 Building and Analyzing CoCharNet

In this paper, we use an annotation strategy to extract CoCharNet. Fig. 2 illustrates an example of an annotation segment;

1. When Character A appears in the scene, this character will be annotated.
2. When Character B appears in the scene, this character will be annotated and the relationship between Character A and Character B will be measured.
3. When Character A leaves the scene, the annotation segment of this character is stopped.
4. When Character B leaves the scene, the annotation segment of this character is stopped.

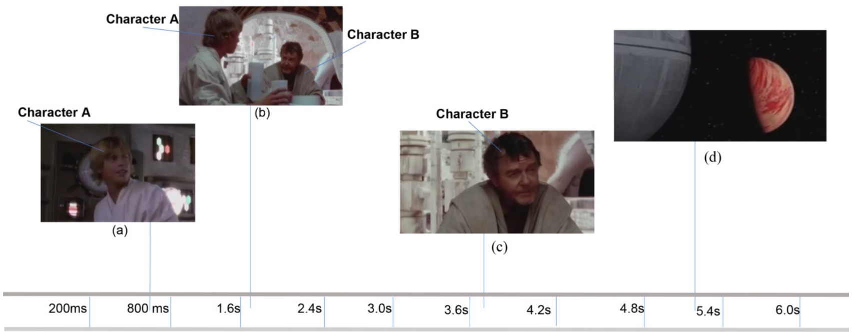

Figure 2: An example of annotation segment

3.1 CoCharNet Formalization

Based on the annotation, the CoCharNet can be built.

Definition 1 (CoCharNet). The CoCharNet is a weighted graph which can be represented as

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

where $C = \{c_1, c_2, ..., c_n\}$ is a set of characters in a movie, and $R \subseteq C \times C$ is represented a set of relationships between the characters.

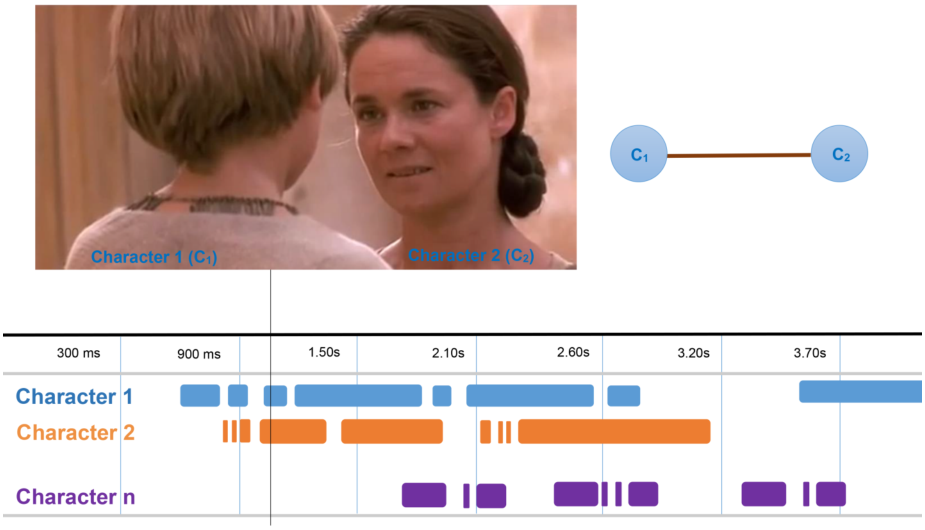

Figure 3: Annotation characters in the movie and the construction of relationships between characters

Fig. 3 illustrates how to create a node and edge in CoCharNet, where C_1 is Character 1 and C_2 is Character 2 and they appear together at a certain time. When the characters appear together at the certain time, CoCharNet updates the nodes and edges of the network by creating new or updated exits. All nodes and edges are calculated from the characters' annotations. If the characters appear together, CoCharNet adds a new node and/or edge in the case where the network does not have the same node or edge, and updates the node and/or edge in the case where the node and/or edge exist.

To extract CoCharNet, we annotate the appearance and co-occurrence of the characters in the movie. CoCharNet annotates characters when they appear on the scene. As shown in Fig. 4, when a character appears in the scene, CoCharNet stores and calculates the frequency and density with which the characters appeared in the movie. The appearance of the characters is considered during the movie play. We also aim to classify the relationship between characters. In this research, the relationships between characters are discovered when the characters appear at the same time or in related-scenes. If the characters appear at the same time, we assume that there is a strong relationship between them. Therefore, we quantify the characters' relationships as the number of appearances in the scenes.

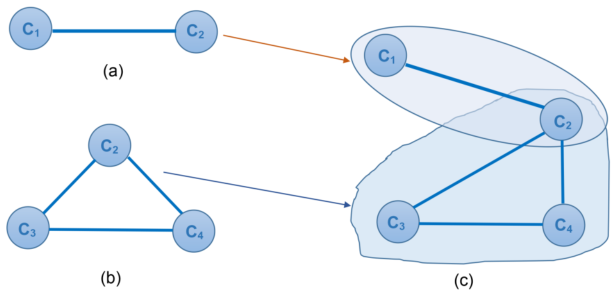

Figure 4: CoCharNet construction. (a) Two characters (i.e., C_1 and C_2) appear together; (b) Three characters (i.e., C_2, C_3 and C_4) appear together; (c) CoCharNet

In the CoCharNet, the social network from movies is extracted based on characters' annotation, the relationships between characters, and the strength of the relationships between characters. In the CoCharNet graph, the nodes represent the characters, the edges represent the relationships between characters, and the width of edges represents the strength of the relationship. Assume that a movie has m minutes length and n characters that are annotated, and R could be measured by the W matrix that represents the weight of relationships between characters.

Definition 2 (Relationship). Relationship R is represented as a matrix which consists of a set of elements.

Definition 3 (Annotation Matrix). Annotation matrix A is measured by

$$A = \langle \tau_s, \tau_e, C_t \rangle \tag{1}$$

where τ_s: the start time on the movie that characters are appeared, τ_e: the end time on the movie that characters are appeared and C_t is a subset of characters C, $C_t = \{c_{t_1}, c_{t_2}, \ldots\}$ are characters that belong to time $\tau_e - \tau_s$.

A movie τ is a set of τ_i, where τ_i is each millisecond of the movie. Each τ_i shows the appearance of characters at that time. The appearance of the character in the time interval of play will be recorded as the annotation matrix A. The

R matrix denotes the relationships between characters. Using this co-occurrence matrix, we can identify and measure the weight of the relationship between the i^{th} and the j^{th} character.

3.2 Extracting CoCharNet

CoCharNet uses the annotation data of a character to extract a social network based on the appearance of the characters in the movie. We can determine the appearances of characters in a movie using several approaches, such as by determining when they appear together, co-occurrence frequency, character appearance, etc. In this paper, we use the appearance of the characters during movie play to measure, evaluate, and analyze the social network. Two methods are used in this research as described below.

3.2.1 Total time of character appearance

We measure the weight of the relationship between characters based on the total time of co-occurrence in the movie. Once the annotation matrix A is obtained, the weight of the relationship between the i^{th} character and the j^{th} character is measured by

$$a_{ij} = \sum_{k=1}^{n} (\tau_k c_i c_j | (c_i, c_j \in C; \{c_i, c_j\} \subseteq C_t; k = 0..n)) \ . \qquad (2)$$

where $\tau_k c_i c_j = 1$ at the time when character c_i appears together with character c_j, measured in milliseconds; c_i and c_j are the characters in C, and n is the total length of the movie in milliseconds. Then, a_{ij} is normalized to $[0, 1]$ by $MAX(a_{ij})$. We can have a weight matrix $W = \frac{a_{ij}}{MAX(a_{ij})}$ that is represented for a total time of a character's co-occurrence in the movie.

3.2.2 Number of co-occurrences between characters

Given the annotation matrix A, we can calculate the weight of the relationship between the i^{th} character and the j^{th} character based on the number of co-occurrences measured by counting the number of times characters appear together. This can be computed by

$$b_{ij} = \prod_{k=1}^{n} (\tau_e - \tau_s | (c_i, c_j \in C; \{c_i, c_j\} \subseteq C_t; \tau_k \subseteq \tau_e - \tau_s; k = 0..n)) \ . \qquad (3)$$

where τ_s and τ_e are the times when co-occurrences between two characters $c_i and c_j$ start and end, respectively. Also, n is the total length of the movie in milliseconds. We also normalize $W' = \frac{b_{ij}}{MAX(b_{ij})}$. Here, W and W' should be used as the weight matrix in CoCharNet, as they have the same role of measuring the strength of relationships between characters in the movie. We can also measure the total time the character appears in the movie by

$$T(c) = \sum \left(\tau_k c_i | \left(c_i \in C\}\right), k = [1, n]\right) \tag{4}$$

where $\tau_k c_i$ is the length of time k a character appears in the movie and n is the total length of the movie in milliseconds.

Based on the total time of the character appearance in the movie, we can measure the score of appearance by

$$S(c) = \frac{T(c_i)}{MAX(T(c_i))}. \tag{5}$$

The score of appearance then uses part of the equations when we identify the protagonist of the movie.

3.3 Social Network Analysis on CoCharNet

The most important aspect of movie analysis is determining the most important characters in the movie. After calculating the relationship matrix W and W', we evaluate the CoCharNet using Betweenness Centrality, Closeness Centrality, and Weighted Average. The centrality values determine the importance of a character. Based on the centrality values of the characters, we can determine the characters that are important in the movie.

Betweeness Centrality of a node c is given by

$$B(c) = \sum_{s \sharp c \sharp t} \frac{\xi_{st}(c)}{\xi_{ij})} \tag{6}$$

where $\xi_{st}(c)$ is the number of shortest paths from node s to node t that pass through c and ξ_{st} is the total number of shortest paths from node s to node t. We also known that the Betweenness Centrality of a node scales with the number of pairs of nodes as implied by the summation indices, so the calculation may be rescaled by dividing through by the number of pairs of nodes not including c, therefore $B \in [0, 1]$. The division is computed by

$$\frac{(N-1)(N-2)}{2}. \tag{7}$$

where N is the number of nodes in the network. Note that this scales for the highest possible value, where one node is crossed by every single shortest path. A normalization of Betweenness Centrality can be performed as

$$normal(B(c)) = \frac{B(c) - min(B)}{max(B) - min(B)} \tag{8}$$

which results in $max(normal) = 1$ and $min(normal) = 0$.

Closeness Centrality is based on the length of the average shortest path between a vertex and all vertices in the graph is given by

$$C(c) = \frac{1}{\sum_s \xi_{cs}} \tag{9}$$

where c is the node to evaluate, s is another node in the network, and ξ_{cs} is the shortest distance between these two nodes c and s.

Weighted Degree of the social network could be measured by

$$\Psi(c) = \sum_{j \in \pi(i)} w_{ij} \tag{10}$$

where w_{ij} is strength of relationship between i^{th} character and j^{th} character, and $\pi(i)$ is the neighborhood of node i.

In the movie, the characters are important factors in the story analysis and content. It is easy to determine which character is the "main character" or the "protagonist" and "minor character". The main character is the player through whom the audience experiences the story first hand and the minor character supports the main character in the movie story [Phillips and Huntley 2001].

CoCharNet applies the Betweenness Centrality, Closeness Centrality, and Weighted Degree measurement to evaluate the importance of characters by using Eqs. 7, 10, and 11. The results of the evaluation session are used to measure the importance of characters in the movies and to classify them into different communities of Main Characters and Minor Characters. The Main Character class includes characters that are most important in the movie. The Minor Character class includes characters that support the main character but appearance and co-occurrence with between of characters in the movie with threshold value. By using the social network evaluation technique, we can classify characters into classes as follows:

- Main Character: A character that has a value of evaluation greater than the average value.
- Minor Character: A character that has a value of evaluation smaller than the average value.

Given the measurements, the average values could be measured, as shown in Table 1.

Using the average threshold to classify the character in certain communities should help us to understand the movie. Classification of the Main Characters class and Minor Characters class over the average value helps us to understand the importance of the characters in the movie. To identify the main character

Measurement	Formula
Average of Betweenness Centrality	$Average_{BC} = \frac{\sum(B_i(c))}{n}$
Average of Closeness Centrality	$Average_{CC} = \frac{\sum(C_i(c))}{n}$
Average of Weighted Degree	$Average_{\Psi C} = \frac{\sum(\Psi_i(c))}{n}$

Table 1: Average centrality measures (n is number of characters are used to annotated in the movie)

in the movie, we use the average of the Score of appearance and the Closeness Centrality, Betweenness Centrality, and Weighted Degree by computing

$$Importance_{C_i} = S(c_i) * B(c_i) * C(c_i) * \frac{\Psi(c_i)}{MAX(\Psi(c_i))} \ . \tag{11}$$

where c_i is the i^{th}character, $S(c_i)$ is the Score of appearance value; $B(c_i)$ is Betweenness Centrality value; $C(c_i)$ is the Closeness Centrality, Ψ_i is the Weighed Degree in the movie.

4 Experimental results

We selected six movies from the Star Wars series: *Star Wars series: Episode I, II, III, IV, V, VI* to extract the CoCharNet. Among the characters in these movies were annotated by time appeared and disappeared during movie play. To extract the CoCharNet, we must perform a technique such as centrality measurement, co-occurrence measurement, or social network analysis and representation. We extract CoCharNet using the social network technique with the co-occurrence and total time characters appear together during the movie, and analyzed this using the character classification and social network evaluation strategy. The environment of the CoCharNet system was implemented in Java with Vlcj[2] and Gephi API[3].

CoCharNet is a social network extracted from the annotation of a character in a movie with nodes representing characters, edges representing the relationships between characters, and the thickness of the edge representing the strength of the relationship.

A list of movies that we have annotated to extract CoCharNet is shown in Table 2. More than 60 characters were annotated with more than 750 minutes of movie play. We annotated the total 100% time of movie play that each character appeared, when characters appeared together, and the number of co-occurrences

[2] Caprica. http://www.capricasoftware.co.uk/projects/vlcj/index.html
[3] Gephi API. https://gephi.org/docs/api/

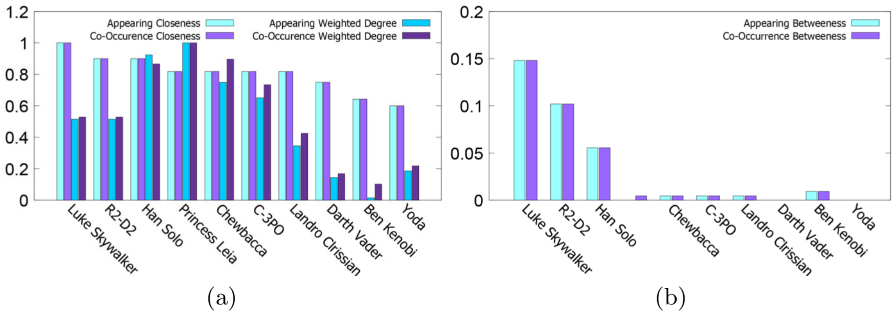

Figure 5: The Centrality of the characters in the movie The Empire Strikes Back. (a) Closeness Centrality and Weighted Degree; (b) Betweeness Centrality

of characters. Therefore, it is more comprehensive than RoleNet and Characternet analysis.

ID	Movie title	Length	Number of character	Release date
A1	Episode I: The Phantom Menace	136 mins	10	1999
A2	Episode II: Attack of the Clones	142 mins	10	2002
A3	Episode III: Revenge of the Sith	140 mins	11	2005
A4	Episode VI: A New Hope	121 mins	11	1977
A5	Episode V: The Empire Strikes Back	124 mins	10	1980
A6	Episode VI: Return of the Jedi	134 mins	12	1983

Table 2: Information of the annotated movies

Table 3 shows the results of Closeness Centrality, Betweenness Centrality, and Weighted Degree measured by CoCharNet from Star Wars Episode V, The Empire Strikes Back. These results are also illustrated in Fig. 5. We can see in this result that the most importance characters always have a high value of measurement.

Fig. 6 illustrates the CoCharNet Annotation and Social Network Extraction system; this system could help us to extract and visualize the network of characters in the movie. During movie play, we can see the network and determine the most important character in the movie, the number of relationships the character has, and the importance of the character. We can also update the social network easily by making a new annotated session.

Total time of characters appear together				
ID	Character Name	Closeness	Betweeness	Weighted
1	Luke Skywalker	1.0000	0.1481	0.5153
2	Han Solo	0.9000	0.0556	0.9243
3	R2-D2	0.9000	0.1019	0.2673
4	Princess Leia	0.8182	0.0046	1.0000
5	Landro Clrissian	0.8182	0.0046	0.3459
6	C-3PO	0.8182	0.0046	0.6510
7	Chewbacca	0.8182	0.0046	0.7494
8	Darth Vader	0.7500	0.0000	0.1442
9	Ben Kenobi	0.6429	0.0093	0.0156
10	Yoda	0.6000	0.0000	0.1860
Number of co-occurrence				
ID	Character Name	Closeness	Betweeness	Weighted
1	Luke Skywalker	1.0000	0.1481	0.5281
2	Han Solo	0.9000	0.0556	0.8663
3	R2-D2	0.9000	0.1019	0.3742
4	Princess Leia	0.8182	0.0046	1.0000
5	Landro Clrissian	0.8182	0.0046	0.4247
6	C-3PO	0.8182	0.0046	0.7337
7	Chewbacca	0.8182	0.0046	0.8966
8	Darth Vader	0.7500	0.0000	0.1685
9	Ben Kenobi	0.6429	0.0093	0.1022
10	Yoda	0.6000	0.0000	0.2180

Table 3: The Centrality measure from the Star Wars Episode V. The Empire Strikes Back

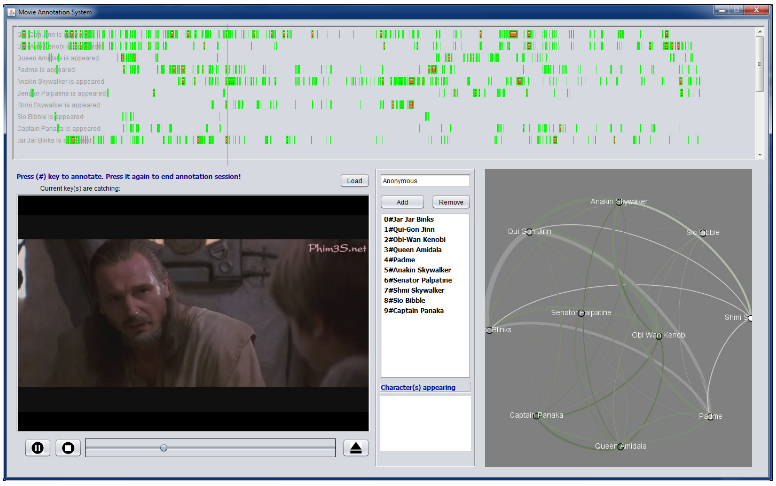

Figure 6: CoCharNet Annotation and Social Network Extraction System

ID	Method	Main character(s)	Minor character(s)
A1	M1. Total time appearing together	1,2,3,4,5,6	7,8,9,10
	M2. Number of co-occurrence	1,2,3,7,4,5,6	7,8,9,10
	IMDB	2,3,4,5,7,8	1,6,9,10
A2	M1. Total time appearing together	1,2,3,4,5,6	7,8,9,10
	M2. Number of co-occurrence	1,2,3,4,5	6,7,8,9,10
	IMDB	1,2,3,7,8	4,5,6,9,10
A3	M1. Total time appearing together	1,2,3,4	5,6,7,8,9,10,11
	M2. Number of co-occurrence	1,2,3,4	5,6,7,8,9,10,11
	IMDB	1,2,5,6,8	3,4,7,9,10,11
A4	M1. Total time appearing together	1,2,3,4,5	6,7,8,9
	M2. Number of co-occurrence	1,3,4,5	2,6,7,8,9
	IMDB	1,2,3,4,6	7,8,9
A5	M1. Total time appearing together	1,2,3,4,5,6,7	8,9,10
	M2. Number of co-occurrence	1,2,3,4,5,6,7	8,9,10
	IMDB	1,3,4,5,6	7,8,9,10,2
A6	M1. Total time appearing together	1,2,3,4,5,6	8,9,10,11,12
	M1. Number of co-occurrence	1,2,3,4,5,6	7,8,9,10,11,12
	IMDB	1,2,3,4,5	6,7,8,9,10,11,12

Table 4: Classes classification by Closeness Centrality

The centrality values are used to classify the characters in the movie into certain classes. The Main Characters Class is that where the centrality value is greater than the Average values measured from Eqs. 12, 13, and 14. The results of the characters classification are shown in Tables 3, 4, and 5; these results are compared with the classification of the IMDb database [IMDB 2014]. With the IMDb database, the first five characters are listed in the stars list of casts and crews belonging to the Main Characters class and other characters belong to the Minor Character class.

Tables 3, 4, and 5 show the results of the classification of six movies measured and evaluated using the social network strategy. Characters are classified into the Main Characters class and Minor Character class and are compared with the real data from the IMDb database.

In comparison to RoleNet and Character-net, our method is more competent because in our proposed method we annotate all appearances and exits of characters in the movie during play. We could therefore consider all the appearances of a character in a scene, and thus provide a better analysis of movie content and relationships between characters.

Fig. 7 illustrates the precision and recall of the proposed method. When using Closeness Centrality, the Main Characters class is determined with a precision of 74.16% and a recall of 71.89% on average. The Minor Characters class is determined with a precision of 67.5% and a recall of 71.32% on average (i.e., Figs. 7(a) and 7(b)). When using the Weighted Degree measurement and evaluation, the Main Characters class is determined using Closeness Centrality with a precision of 70% and a recall of 78% on average. The Minor Characters class was

ID	Method	Main character(s)	Minor character(s)
A1	M1. Total time appearing together	1,2,3	4,5,6,7,8,9,10
	M2. Number of co-occurrence	1,2,3,7	4,5,6,8,9,10
	IMDB	2,3,4,5,7,8	1,6,9,10
A2	M1. Total time appearing together	1	2,3,4,5,6,7,8,9,10
	M2. Number of co-occurrence	1	2,3,4,5,6,7,8,9,10
	IMDB	1,2,3,7,8	4,5,6,9,10
A3	M1. Total time appearing together	1,2,3	4,5,6,7,8,9,10,11
	M2. Number of co-occurrence	1,2,4	3,5,6,7,8,9,10,11
	IMDB	1,2,5,6,8	3,4,7,9,10,11
A4	M1. Total time appearing together	1,2	3,4,5,6,7,8,9
	M2. Number of co-occurrence	1	2,3,4,5,6,7,8,9
	IMDB	1,2,3,4,6	7,8,9
A5	M1. Total time appearing together	1,2	3,4,5,6,7,8,9,10
	M1. Total time appearing together	1,2,3	4,5,6,7,8,9,10
	IMDB	1,3,4,5,6	7,8,9,10,2
A6	M1. Total time appearing together	1,2,3,4	5,6,7,8,9,10,11,12
	M1. Total time appearing together	1,2,3,4	5,6,7,8,9,10,11,12
	IMDB	1,2,3,4,5	6,7,8,9,10,11,12

Table 5: Classes classification by Betweenness Centrality

ID	Method	Main character(s)	Minor character(s)
A1	M1. Total time appearing together	1,2,3,4,7	5,6,8,9,10
	M2. Number of co-occurrence	1,3,4,5,7	2,6,8,9,10
	IMDB	2,3,4,5,7,8	1,6,9,10
A2	M1. Total time appearing together	1,2,7	3,4,5,6,8,9,10
	M2. Number of co-occurrence	1,7,2,4,3	5,6,8,9,10
	IMDB	1,2,3,7,8	4,5,6,9,10
A3	M1. Total time appearing together	1,2,5,6	4,7,8,9,10,11
	M2. Number of co-occurrence	1,2,6,3	5,7,8,9,10,11
	IMDB	1,2,5,6,8	3,4,7,9,10,11
A4	M1. Total time appearing together	1,2,4	3,5,6,7,8,9
	M2. Number of co-occurrence	1,3,6,4,9	2,5,7,8,9
	IMDB	1,2,3,4,6	7,8,9
A5	M1. Total time appearing together	4,2,6,7,1	3,5,8,9,10
	M2. Total time appearing together	4,7,2,6	1,3,5,8,9,10
	IMDB	1,3,4,5,6	2,7,8,9,10
A6	M1. Total time appearing together	1,2,3,4,6	5,7,8,9,10,11,12
	M2. Total time appearing together	1,2,3,4,6	5,7,8,9,10,11,12
	IMDB	1,2,3,4,5	6,7,8,9,10,11,12

Table 6: Classes classification by Weighted Degree

determined with a precision of 81% and a recall of 69% on average (i.e., Figs. 7(c) and 7(d)). However, when using the Betweenness Centrality measurement strategy, the Main Characters class was obtained with a precision of 40.28% and a recall of 79.86% on average. The Minor Characters class was obtained with a precision of 89.72% and a recall of 56.62% on average, because this method only considers the number of co-occurrences of characters, and in some action scenes, characters appear, exit, and co-occur very frequently (i.e., Figs. 7(e) and 7(f)).

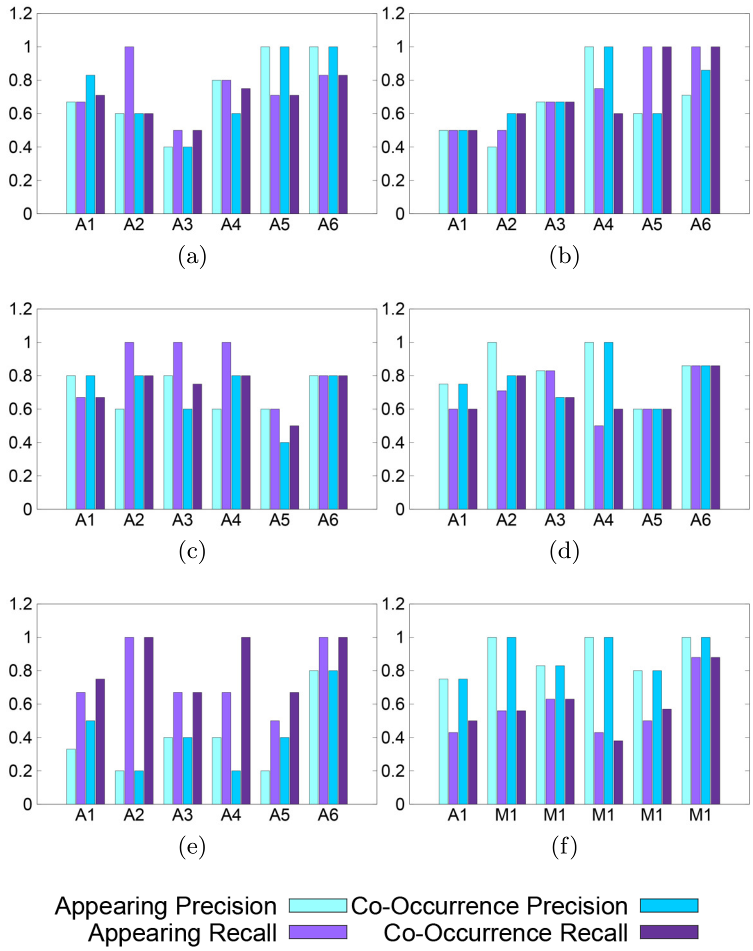

Figure 7: Precision and Recall evaluation. (a) Main Character classification; (b) Minor Character classification using Closeness Centrality measurement; (c) Main Character classification; (d) Minor Character classification using Weighted Degree measurement; (e) Main Character classification; (f) Minor Character classification using Betweenness Centrality measurement

In the movie story, it is very useful to know which is the hero or main character. Our proposed method could measure the total time the character appears in the movie and combine this with the Closeness Centrality, Betweenness Centrality, and Weighted Degree measurement and evaluation. We can then determine the protagonist character (known as the hero or main character) in the movie as shown in Table 7. The results of the Protagonist evaluation and measurement

	Episde I	Episde II	Episde III	Episde IV	Episde IV	Episde VI
Proposed	Jinn	Kenobi	Kenobi	Luke	Luke	Luke
In IMDb	Jinn	Kenobi	Kenobi	Luke	Luke	Luke

Table 7: The most important character measured by CoCharNet

are similar to the classification in the IMDb database [IMDB 2014]. Using this evaluation, we could create a movie story segmentation, but we will explain this further in a future plan if we wish to determine the relationships between the characters.

5 Discussion

The experimental results show that CoCharNet is a method that can be used to analyze a movie using social network measurement and evaluation strategy. We depict CoCharNet as a social network and produce a graph in which the nodes represent characters, the edges represent the relationships between characters, and the thickness of the edge represents the strength of the relationship. In our proposed method, we use social network measurement and evaluation as principles to classify characters into Main Characters class and Minor Characters class by using Closeness Centrality, Betweenness Centrality, and Weighted Degree measurement and evaluation. Compared to RoleNet and Character-net, RoleNet uses face recognition to measure the co-occurrence of the characters in the movie, and classifies characters into leader role and extra role to analyze the movie story. Character-net uses dialog to measure and classify characters into major roles, minor roles, and extra roles. However, neither of these methods could identify the main character as the protagonist or the hero in the movie. Additionally, neither RoleNet nor Character-net could measure all of the cases in the movie such as the main character, the cases in which the character appears alone or the case in which dialog between characters is lacking. We compared the result of the proposed method with the IMDb database [IMDB 2014] and the result is similar to the IMDb ranking of the importance of the characters in the movie. We also found the main character (as the protagonist or the hero) in the movie. This result is matched with IMDb ranking (as shown in Tables 4, 5, 6, and 7).

Annotation is very time consuming. It is not easy to annotate correctly and it requires a significant amount of time. Although this work comprehends all of the appearances of characters in the movie, the proposed method has some limitations such as it only considers the undirected relationship between characters, or the limitation of the number of characters used in the annotation session.

Moreover, movie analysis is not only based on principle characters, since the study of the scene, story segmentation, and clustering is also needed.

As shown in Fig. 1, [Phillips and Huntley 2001] suggests that the importance of movie analysis is determining how to understand and identify characters, character roles, character relationships, etc. This problem will be considered in future work. We plan to improve CoCharNet performance and efficiencies by examining how to analyze the movie using movie story segmentation and analysis.

6 Conclusion

Movie analysis is a widely researched topic and has many interesting concepts and challenges. Recently, understanding a movie and discovering useful information from the movie has become a popular research topic. In this paper, we proposed CoCharNet, a method used to extract the social network in the movie using character annotation, measured using social network analysis and evaluation technology. Based on CoCharNet, we can discover the story of the movie through character appearance and relationships between characters. Our proposed method provides a new concept to discover useful information in the movie such as the characters' importance, character relationships, and understanding of the movie's story. CoCharNet discovers the character relationships by annotation and analyzes them using social network measurement and evaluation. The important characters and character relationships are measured using the Betweenness Centrality, Closeness Centrality, and Weighted Degree strategy. Through these measurement results, we classify characters into certain classes such as Main Characters class and Minor Character class. We developed a CoCharNet system to annotate, visualize, measure, and evaluate our proposed method by comparing with real data from IMDb's list of casts and crews. We applied CoCharNet on the Star Wars series of six movies, with more than 60 characters and more than 750 minutes of movie play. The experiment session showed the performance and efficiency of the proposed method.

Despite having better results of movie analysis, our proposed method still has some limitation and weakness. It still has some incorrect classification of characters. These limitations will be considered in future work that will develop CoCharNet to be more efficient and have better performance. The future works will consider scenes and movie segmentation, through which the movie story will be easier and more efficiently discovered and understood. We plan to consider the time stamp of subtitles and speech recognition to understand the Subjective Throughline and Character Throughline in the movie. For example, we can discover and analyze the relationships between the Protagonist and Antagonist, Rational and Emotional, Sidekick and Septic, Guardian and Contagonist in the movie. We will improve the performance and efficiency of CoCharNet through deeper and wider analysis than Character-net and Rolenet. By attempting this, we will use CoCharNet to analyze the more semantic aspects (meaning, features or relations) of a movie.

Acknowledgments

This work was supported by the ICT R&D program of MSIP/IITP [10035348, Development of a Cognitive Planning and Learning Model for Mobile Platforms]. Also, this work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. NRF-2014R1A2A2A05007154).

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