# Network Analysis of Dark Characters

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## Declaration

This report has been prepared on the basis of my own work, And no other published or unpublished source materials have been used, these have been acknowledged.

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# Abstract:

This Network analysis is a mathematical technique which utilizes mathematical graph theory to analyze and establish unique and important connections over a network. The network here could be anything ranging from a social network like Facebook to a simple developer community in our college. Most of the analysis I do in this field is quantitative instead of qualitative. Using tools like centrality measure and betweenness centrality, we tend to find densely populated nodes in a network. By doing so, I want to see how I can combine the real world with the digital world to find meaningful relationships that can exist between different people. With over 150+ characters and 80+ support cast it is one the world's most cast intensive tv shows employing the knowledge of network theory. We would do a detailed analysis of these characters and would deduce season wise important characters/roles. We would use a static dataset instead of a streaming one. In this dataset the name of the characters has been categorized into season wise comma separated value files (CSV file). Here the characters are treated as nodes of the network while the weight of the edges corresponds to the total no of interaction.

# 1) Introduction

Audiences from all across the world have always found the world of television shows to be endlessly interesting. Some television series have become extremely complicated, with over 150 main characters and 80 or more supporting cast members, making it difficult to comprehend the nuanced nature of the interpersonal interactions and dynamics among the characters. On the other hand, since the development of network theory and mathematical graph theory, it has become feasible to investigate and identify connections within a network that are both unique and significant. In this regard, the purpose of this research is to study one of the world's most cast-intensive television shows of all time by making use of network theory to identify essential characters and their roles season by season. This project attempts to link the actual world with the digital world in order to uncover significant interactions that can exist between different characters. To do this, the project will use techniques such as centrality measures and betweenness centrality. The information that was used for this research is a static one, and the names of the characters were organized into comma separated value files according to the season in which they appeared (CSV files). This analysis will allow us to get insights into the network structure of the TV show, as well as the relevance of the characters and the interactions between them. These insights will pave the way for additional research and a better understanding of the overall narrative of the TV show.

Analyzing the relationships between characters in a web series using centrality measures such as betweenness centrality and closeness centrality can provide valuable insights into the dynamics of the story and the characters themselves. However, despite the potential benefits of this approach, there is currently a lack of research on the use of centrality measures in analyzing web series and other forms of digital media. By conducting a thorough analysis of the relationships between characters in a web series using centrality measures, this research paper aims to fill this gap in the literature and contribute to our understanding of the role of network analysis in digital media studies. The results of this study may have implications for the fields of media studies, social network analysis, and digital humanities, among others. Furthermore, by focusing specifically on web series, this research paper addresses a rapidly growing area of media production that has received relatively little attention from scholars to date. As web series continue to gain popularity and cultural significance, it is important to develop new methods of analysis that can help us understand the unique features and challenges of this emerging form of media. Overall, this research paper has the potential to make an important contribution to the field of media studies and provide new insights into the relationship between network analysis and digital media.

# 2) Literature Survey

| Sl.No | Author/Year | Title | Methodology | Observation |
|---|---|---|---|---|
| 1 | Dianbo Liu and Luca Albergante | Balance of thrones: a network study on Game of Thrones. | Construction of relationship network and then identifying the dynamics of the network which involves comparing nodes, network graph to show the relationships of characters. | the authors try to find out the relation between audience engagement and network features and represent it as a graph. |
| 2 | Lei Ding & Alper Yilmaz | Learning Relations among Movie Characters: A Social Network Perspective.. | Attempt to construct social networks, identify communities and find the leader of each community in a video sequence from a sociological perspective using computer vision and machine learning techniques. | The framework was able to successfully determine the leader of a community of characters in a movie and that it can be applied in other domains as well such as video. Surveillance |
| 3 | Chung-Yi Weng, Wei-Ta Chu et al. | Movie analysis based on roles' social network. | The first thing that the research does is constructing the social network and reading it, after that it identifies the leading roles in the show or movie and identifies its community along with detecting the storyline of the given movie. | The authors construct a roles' social network and identify the embedded community. The results show the effectiveness and capability to handle errors of the system |
| 4 | Tong Zhao | Understanding Gender Inequality in Movie Industry using Social Network Analysis and Machine Learning Bechdel test | The identify equality or inequality, it is a set of parameters that if qualified then the movie is not gender biased. | A dataset of movies with script is used and its social network is constructed along with the calculation of various centrality measures and finally results are calculated. paper finds that female actors generally occupy less important social positions and plays a less important role in the social networks in almost all genres. This is even prevalent in Romance and Family |

| | | | | |
|---|---|---|---|---|
| | | | | movies. So, social network analysis can help in predicting gender disparity among movies. |
| 5 | Krauss, Jonas; Nann | Predicting Movie Success and Academy Awards through Sentiment and Social Network Analysis. | Proposes a new web Au mining approach that to f combines social network analysis and patt sentiment analysis, the pred authors conducted many experiments by examining the correlation of the social network structure with external Oscar metrics such as box given office revenue and Oscar Awards and predic then predicting the success and award getting possibility mining using the movie content. | Authors are able to find that discussion patterns on IMDb predict Academy Awards nominations and box office success. Two months before the Oscars were given they were able to correctly predict nine Oscar nominations using the new web mining approach (social network+ sentiment analysis). |

# Gaps In Literature Survey:

While there is a significant corpus of research on social and information networks, there is a gap in our understanding of how the structure of networks influences the diffusion of information within them.
Research on the effects of social network analysis in real-world contexts is limited. Although social network analysis has been extensively utilised in academic settings, there is a lack of knowledge regarding its application in the real world and its accuracy in predicting outcomes.
Insufficient consideration of ethical factors: The ethical issues raised by social and information networks include privacy, bias, and impartiality. However, there is a dearth of research examining these issues, and few studies have proposed practical solutions for addressing them.
Studies have identified gender disparities in social networks, but there is a lack of comprehension of how other aspects of identity, such as race, class, and sexual orientation, intersect to produce unique experiences of exclusion or inclusion within social networks.
Limited research on social media's effect on social and information networks: There is a lack of knowledge regarding how social media influences social and

information networks, such as how it influences the formation of social ties and the dissemination of information within networks.

# 3) Modules

## Overview

The project has the potential to provide valuable insights into the relationships between Dark series characters and enhance the audience's understanding of the story. The network analysis and interactive HTML page could offer a new perspective on the story, potentially revealing connections and insights that were not immediately apparent.

## Overall Architecture Diagram

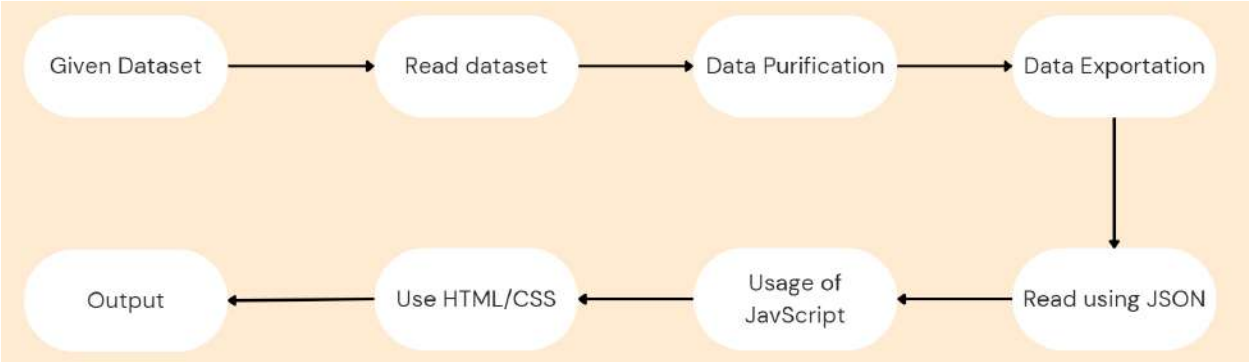


Fig. 3.1: Architectural Diagram, describing the steps of the system.

## Subsystem and Modules

Few modules that were used are:

1) *beautifulsoup4:* Web scraping, often known as "bathing," is the process of gathering data from webpages. Beautiful Soup is a Python package that is used for this operation. It offers a straightforward method for parsing HTML and XML documents and obtaining the pertinent information from those files. Moreover, it has the ability to explore the parse tree in a flexible manner, which makes it much simpler to extract certain pieces of data from complicated HTML texts.

2) *Pandas:* Pandas is a library written in Python that may be used to manipulate and analyse data. It was developed on top of NumPy and offers data structures and data analysis capabilities that are simple to work with. It is especially helpful for working with tabular data, such as the data found in spreadsheets or SQL tables, and it is able to carry out operations such as filtering, grouping, and merging data sets.

3) *tqdm:* TQDM is a library written in Python that is utilised in the creation of progress bars for command-line interfaces (CLI). It offers a straightforward method for displaying the progression of a lengthy operation, such as the loading of data or the analysis of data, and it may be modified to fulfil individualised requirements. It is very helpful for making the command line interface (CLI) simpler and easier to use.

4) *Requests*: Python's Requests module is used for sending HTTP requests and managing answers to such requests. It is especially helpful for web scraping, web application programming interfaces (APIs), and other operations that need to communicate with online services. It offers a straightforward and uncomplicated user interface for sending HTTP requests and managing answers, which includes the management of HTTP errors and redirection.

5) *Urllib3:* Urllib3 is a library for the Python programming language that provides a user interface that is both straightforward and powerful for initiating HTTP requests and managing replies. It is especially helpful for web scraping, web application programming interfaces (APIs), and other operations that need to

communicate with online services. It gives a great degree of flexibility and control over the HTTP requests and answers, in addition to supporting a broad variety of HTTP capabilities such as SSL, connection pooling, and multipart uploads.

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# 4) IMPLEMENTATION

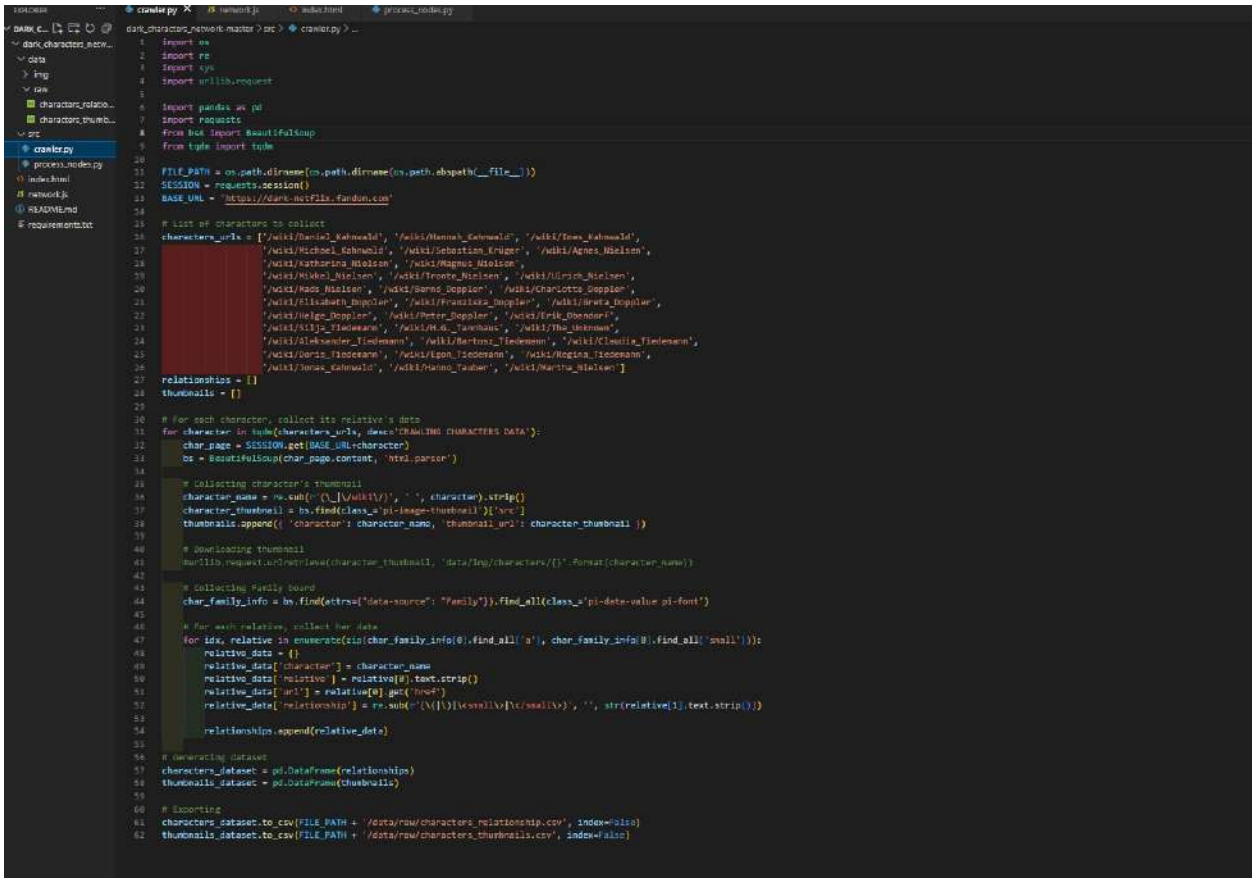
## Methodology

The script is used to process network visualization data involving nodes and edges. Importing essential libraries such as os, re, sys, and pandas is the first step. Then, it specifies the path to the file directory as the constant FILE PATH. After which, it defines a number of regular expressions that are used to filter out undesirable data relationships. Regular expressions are utilized to eliminate great-parent relationships, multiple relationships, and adoptive relationships. The function create relationship() is defined to generate custom character relationships. It takes as input data, from char, to char, and relation and generates a dictionary of the character relationships. The dictionary is then appended to the data frame. The data frame is extracted from the CSV file, and then the undesirable relationships are eliminated using regular expressions. The relationships are capitalized, while meaningless relationships are eliminated. Using the create relationship() function, the script then augments the data frame by adding custom relationships. A CSV file is then created from the enriched data frame. This line is however commented out in the script. The data frame is finally prepared for network visualization. The color and shape columns are created/deleted, and regular expressions are used to determine the hue for each relationship. The data frame is then renamed, and the data is printed in the desired format as a dictionary. In general, the script's methodology entails cleaning and enriching the data by removing unwanted relationships and introducing custom relationships. The data is then prepared for network visualization by applying regular expressions to select colors for each relationship. The data is then printed in the format requested for network visualization. The architectural

diagram for this project consists of several components that work together to transform the given dataset into an interactive network visualization. The first step is to read the dataset, which is likely in a CSV format, and store it in memory. This dataset will contain information about the relationships between characters in the Dark series. Next, the data purification step involves cleaning the dataset by removing any unwanted relationships or data points that may be irrelevant to the visualization. This step could involve using regular expressions or other data manipulation techniques to filter out unwanted information. After the dataset has been purified, data exploration can begin. This step involves analyzing the dataset to gain insights into the relationships between the characters. This step could involve the use of data visualization tools or statistical analysis techniques. Once the data has been explored, it is ready to be used in the network visualization. The dataset can be converted to a JSON format that is easily readable by JavaScript. JavaScript is used to create an interactive network visualization that can be displayed in a web browser. HTML and CSS are used to create the web page that will display the network visualization. HTML is used to structure the content of the page, while CSS is used to style the page and create the visual elements of the network visualization. The output of the architectural diagram is an interactive network visualization that allows users to explore the relationships between the characters in the Dark series. Users can click on a character to see all of their relationships and gain a deeper understanding of their role in the story. The visualization can be accessed through a web browser and can be shared with others to promote further analysis and discussion.

# Source Code:

## crawler.py



```python
import os
import re
import sys
import urllib.request

import pandas as pd
import requests
from bs4 import BeautifulSoup
from tqdm import tqdm

FILE_PATH = os.path.dirname(os.path.dirname(os.path.abspath(__file__)))
SESSION = requests.session()
BASE_URL = 'https://dark-netflix.fandom.com'

# List of characters to collect
characters_urls = ['/wiki/Daniel_Kahnwald', '/wiki/Hannah_Kahnwald', '/wiki/Ines_Kahnwald',
                   '/wiki/Michael_Kahnwald', '/wiki/Sebastian_Krüger', '/wiki/Agnes_Nielsen',
                   '/wiki/Katharina_Nielsen', '/wiki/Magnus_Nielsen',
                   '/wiki/Mikkel_Nielsen', '/wiki/Troute_Nielsen', '/wiki/Ulrich_Nielsen',
                   '/wiki/Mads_Nielsen', '/wiki/Bernd_Doppler', '/wiki/Charlotte_Doppler',
                   '/wiki/Elisabeth_Doppler', '/wiki/Franziska_Doppler', '/wiki/Greta_Doppler',
                   '/wiki/Helge_Doppler', '/wiki/Peter_Doppler', '/wiki/Erik_Obendorf',
                   '/wiki/Silja_Tiedemann', '/wiki/H.G._Tannhaus', '/wiki/The_Unknown',
                   '/wiki/Aleksander_Tiedemann', '/wiki/Bartosz_Tiedemann', '/wiki/Claudia_Tiedemann',
                   '/wiki/Doris_Tiedemann', '/wiki/Egon_Tiedemann', '/wiki/Regina_Tiedemann',
                   '/wiki/Jonas_Kahnwald', '/wiki/Hanno_Tauber', '/wiki/Martha_Nielsen']
relationships = []
thumbnails = []

# For each character, collect its relative's data
for character in tqdm(characters_urls, desc='CRAWLING CHARACTERS DATA'):
    char_page = SESSION.get(BASE_URL+character)
    bs = BeautifulSoup(char_page.content, 'html.parser')

    # Collecting character's thumbnail
    character_name = re.sub(r'(\_|\/wiki\/)', ' ', character).strip()
    character_thumbnail = bs.find(class_='pi-image-thumbnail')['src']
    thumbnails.append({ 'character': character_name, 'thumbnail_url': character_thumbnail })

    # Downloading thumbnail
    urllib.request.urlretrieve(character_thumbnail, 'data/img/characters/{}'.format(character_name))

    # Collecting family board
    char_family_info = bs.find(attrs={"data-source": "Family"}).find_all(class_='pi-data-value pi-font')

    # For each relative, collect her data
    for idx, relative in enumerate(zip(char_family_info[0].find_all('a'), char_family_info[0].find_all('small'))):
        relative_data = {}
        relative_data['character'] = character_name
        relative_data['relative'] = relative[0].text.strip()
        relative_data['url'] = relative[0].get('href')
        relative_data['relationship'] = re.sub(r'(\([\)[\<small\>|\</small\>)', '', str(relative[1].text.strip()))

        relationships.append(relative_data)

# Generating dataset
characters_dataset = pd.DataFrame(relationships)
thumbnails_dataset = pd.DataFrame(thumbnails)

# Exporting
characters_dataset.to_csv(FILE_PATH + '/data/raw/characters_relationship.csv', index=False)
thumbnails_dataset.to_csv(FILE_PATH + '/data/raw/characters_thumbnails.csv', index=False)
```

**Pto**

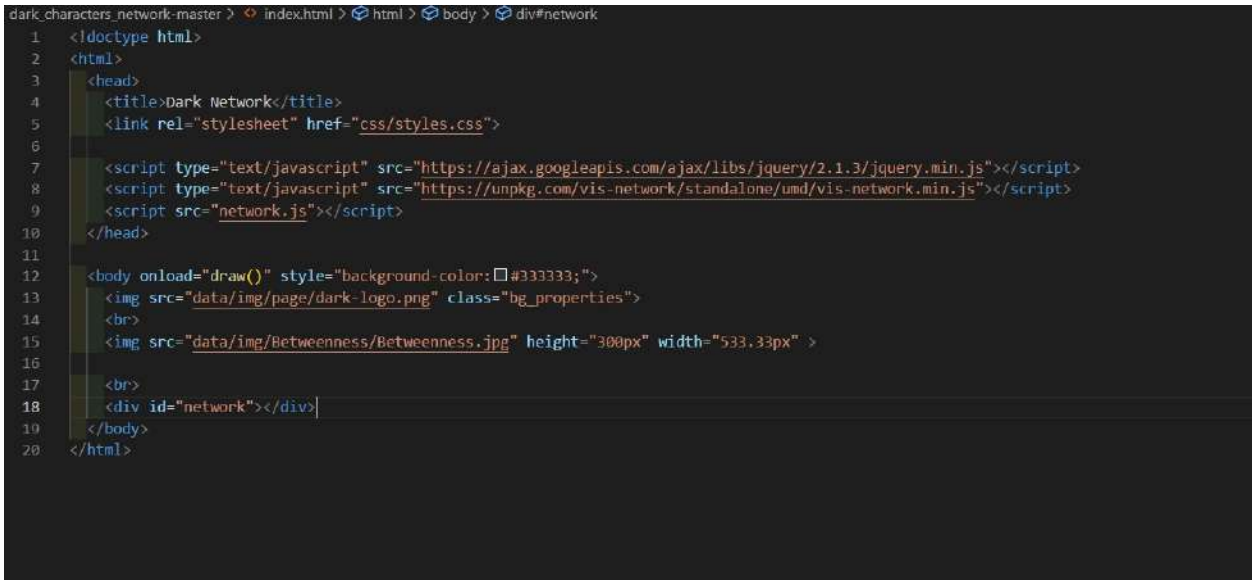
## process_nodes.py

dark_characters_network-master > src > process_nodes.py > ...

```python
'''
Description: Script used to processed the nodes and edges for the network visualization
'''

import os
import re
import sys

import pandas as pd

FILE_PATH = os.path.dirname(os.path.dirname(os.path.abspath(__file__)))
REGEX_GREATPARENTS = '(/|)great-.*(/|)'
REGEX_MULTI_RELATIONSHIP = '(;|,).*'
REGEX_ADOPTIVE = 'adoptive'
REGEX_FIRST_LEVEL_RELATIVES = '(mother|father|sister|brother|wife|husband|son|daughter)'
REGEX_LAW_RELATIVES = '(law)'
REGEX_SECOND_LEVEL_RELATIVES = '(cousin|nephew|aunt|uncle)'
REGEX_GRANDRELATIVES = '(grand)'

def create_relationship(data, from_char, to_char, relation):
    '''
    Function used to create custom relationship between characters
    '''
    relation_dict = ['character': from_char,
                     'relationship': relation,
                     'relative': to_char,
                     'url': data.loc[data['relative'] == to_char, 'url'].iloc[0]
                    }
    data = data.append(pd.DataFrame([relation_dict]))
    return data

data = pd.read_csv(FILE_PATH + '/data/raw/characters_relationship.csv')

# Removing unuseful relationships with regex
data['relationship'] = data['relationship'].str.replace(REGEX_GREATPARENTS, '', case=False)
data['relationship'] = data['relationship'].str.replace(REGEX_MULTI_RELATIONSHIP, '', case=False)
data['relationship'] = data['relationship'].str.replace(REGEX_ADOPTIVE, '', case=False)
```

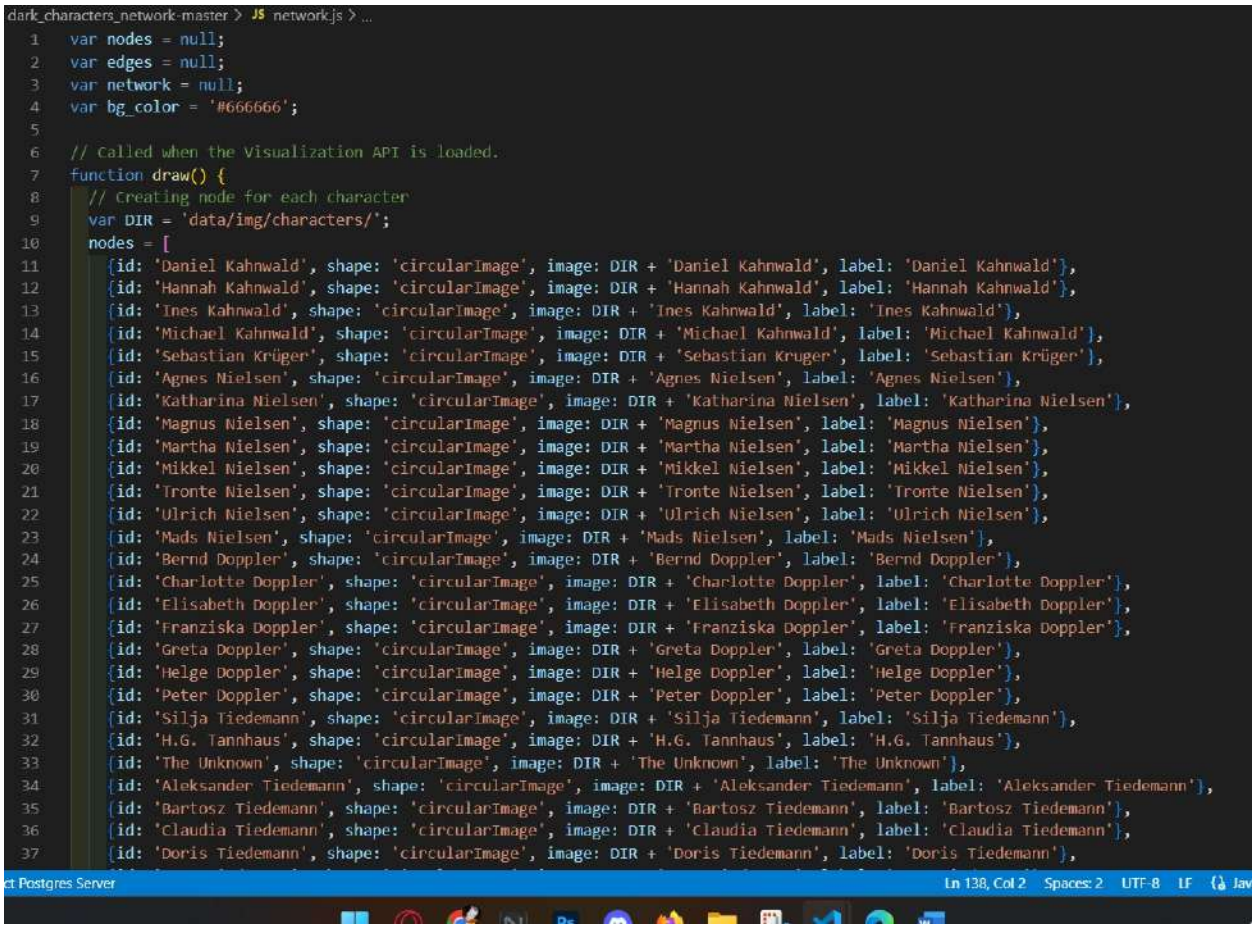
**Pto**

## index.html



```
dark_characters_network-master > index.html > html > body > div#network
<!doctype html>
<html>
  <head>
    <title>Dark Network</title>
    <link rel="stylesheet" href="css/styles.css">

    <script type="text/javascript" src="https://ajax.googleapis.com/ajax/libs/jquery/2.1.3/jquery.min.js"></script>
    <script type="text/javascript" src="https://unpkg.com/vis-network/standalone/umd/vis-network.min.js"></script>
    <script src="network.js"></script>
  </head>

  <body onload="draw()" style="background-color:#333333;">
    <img src="data/img/page/dark-logo.png" class="bg_properties">
    <br>
    <img src="data/img/Betweenness/Betweenness.jpg" height="300px" width="533.33px" >

    <br>
    <div id="network"></div>
  </body>
</html>
```

## network.js



```
dark_characters_network-master > JS network.js > ...
var nodes = null;
var edges = null;
var network = null;
var bg_color = '#666666';

// Called when the Visualization API is loaded.
function draw() {
  // Creating node for each character
  var DIR = 'data/img/characters/';
  nodes = [
    {id: 'Daniel Kahnwald', shape: 'circularImage', image: DIR + 'Daniel Kahnwald', label: 'Daniel Kahnwald'},
    {id: 'Hannah Kahnwald', shape: 'circularImage', image: DIR + 'Hannah Kahnwald', label: 'Hannah Kahnwald'},
    {id: 'Ines Kahnwald', shape: 'circularImage', image: DIR + 'Ines Kahnwald', label: 'Ines Kahnwald'},
    {id: 'Michael Kahnwald', shape: 'circularImage', image: DIR + 'Michael Kahnwald', label: 'Michael Kahnwald'},
    {id: 'Sebastian Krüger', shape: 'circularImage', image: DIR + 'Sebastian Kruger', label: 'Sebastian Krüger'},
    {id: 'Agnes Nielsen', shape: 'circularImage', image: DIR + 'Agnes Nielsen', label: 'Agnes Nielsen'},
    {id: 'Katharina Nielsen', shape: 'circularImage', image: DIR + 'Katharina Nielsen', label: 'Katharina Nielsen'},
    {id: 'Magnus Nielsen', shape: 'circularImage', image: DIR + 'Magnus Nielsen', label: 'Magnus Nielsen'},
    {id: 'Martha Nielsen', shape: 'circularImage', image: DIR + 'Martha Nielsen', label: 'Martha Nielsen'},
    {id: 'Mikkel Nielsen', shape: 'circularImage', image: DIR + 'Mikkel Nielsen', label: 'Mikkel Nielsen'},
    {id: 'Tronte Nielsen', shape: 'circularImage', image: DIR + 'Tronte Nielsen', label: 'Tronte Nielsen'},
    {id: 'Ulrich Nielsen', shape: 'circularImage', image: DIR + 'Ulrich Nielsen', label: 'Ulrich Nielsen'},
    {id: 'Mads Nielsen', shape: 'circularImage', image: DIR + 'Mads Nielsen', label: 'Mads Nielsen'},
    {id: 'Bernd Doppler', shape: 'circularImage', image: DIR + 'Bernd Doppler', label: 'Bernd Doppler'},
    {id: 'Charlotte Doppler', shape: 'circularImage', image: DIR + 'Charlotte Doppler', label: 'Charlotte Doppler'},
    {id: 'Elisabeth Doppler', shape: 'circularImage', image: DIR + 'Elisabeth Doppler', label: 'Elisabeth Doppler'},
    {id: 'Franziska Doppler', shape: 'circularImage', image: DIR + 'Franziska Doppler', label: 'Franziska Doppler'},
    {id: 'Greta Doppler', shape: 'circularImage', image: DIR + 'Greta Doppler', label: 'Greta Doppler'},
    {id: 'Helge Doppler', shape: 'circularImage', image: DIR + 'Helge Doppler', label: 'Helge Doppler'},
    {id: 'Peter Doppler', shape: 'circularImage', image: DIR + 'Peter Doppler', label: 'Peter Doppler'},
    {id: 'Silja Tiedemann', shape: 'circularImage', image: DIR + 'Silja Tiedemann', label: 'Silja Tiedemann'},
    {id: 'H.G. Tannhaus', shape: 'circularImage', image: DIR + 'H.G. Tannhaus', label: 'H.G. Tannhaus'},
    {id: 'The Unknown', shape: 'circularImage', image: DIR + 'The Unknown', label: 'The Unknown'},
    {id: 'Aleksander Tiedemann', shape: 'circularImage', image: DIR + 'Aleksander Tiedemann', label: 'Aleksander Tiedemann'},
    {id: 'Bartosz Tiedemann', shape: 'circularImage', image: DIR + 'Bartosz Tiedemann', label: 'Bartosz Tiedemann'},
    {id: 'Claudia Tiedemann', shape: 'circularImage', image: DIR + 'Claudia Tiedemann', label: 'Claudia Tiedemann'},
    {id: 'Doris Tiedemann', shape: 'circularImage', image: DIR + 'Doris Tiedemann', label: 'Doris Tiedemann'},
ct Postgres Server                                   Ln 138, Col 2  Spaces: 2  UTF-8  LF  Jav
```

dark_characters_network-master > JS network.js > ...

```
// Creating legend
var mynetwork = document.getElementById("network");
var x = -mynetwork.clientWidth / 2 - 1000;
var y = -mynetwork.clientHeight / 2 + 50;
var step = 70;

nodes.push({ id: 1000, x: x, y: y, label: "Family (Father, Daughter, Wife,...) ", group: "family", value: 1, fixed: true, physics: false });
nodes.push({ id: 1001, x: x, y: y + step, label: "Uncles, Aunts, Cousins, and Aunts", group: "first_relatives", value: 1, fixed: true, physics:
false });
nodes.push({ id: 1002, x: x, y: y + 2 * step, label: "Grandparents", group: "grand_parents", value: 1, fixed: true, physics: false });
nodes.push({ id: 1003, x: x, y: y + 3 * step, label: "In-law Relatives", group: "in_law_relatives", value: 1, fixed: true, physics: false });
nodes.push({ id: 1004, x: x, y: y + 4 * step, label: "Killed by", group: "killed", value: 1, fixed: true, physics: false }),
nodes.push({ id: 1005, x: x, y: y + 5 * step, label: "Others relationships (e.g. lovers)", group: "other", value: 1, fixed: true, physics:
false });

// Create a network
var container = document.getElementById('network');
var data = {
  nodes: nodes,
  edges: edges
};

var options = {
  width: (window.innerWidth - 25) + "px",
         height: (window.innerHeight - 75) + "px",
  nodes: {
    borderWidth: 4,
    size: 50,
  color: {
      border: '#222222',
      background: bg_color
    },
    font:{color:'#eeeeee'}
  },
  edges: {
    color: bg_color,
```

**Pto**

## character_relationship.csv

dark_characters_network-master > data > raw > characters_relationship.csv

```
character,relationship,relative,url
Daniel Kahnwald,Daughter,Ines Kahnwald,/wiki/Ines_Kahnwald
Daniel Kahnwald,Adoptive Grandson,Michael Kahnwald,/wiki/Michael_Kahnwald
Daniel Kahnwald,Adoptive Granddaughter In-Law,Hannah Kahnwald,/wiki/Hannah_Kahnwald
Daniel Kahnwald,Adoptive Great-Grandson,Jonas Kahnwald,/wiki/Jonas_Kahnwald
Hannah Kahnwald,father,Sebastian Krüger,/wiki/Sebastian_Kr%C3%BCger
Hannah Kahnwald,husband/great-great-great-grandson,Michael Kahnwald,/wiki/Michael_Kahnwald
Hannah Kahnwald,son,Jonas Kahnwald,/wiki/Jonas_Kahnwald
Hannah Kahnwald,daughter,Silja Tiedemann,/wiki/Silja_Tiedemann
Hannah Kahnwald,grandson,The Unknown,/wiki/The_Unknown
Hannah Kahnwald,grandson,Hanno Tauber,/wiki/Hanno_Tauber
Hannah Kahnwald,granddaughter,Agnes Nielsen,/wiki/Agnes_Nielsen
Hannah Kahnwald,great-grandson,Tronte Nielsen,/wiki/Tronte_Nielsen
Hannah Kahnwald,great-granddaughter,Charlotte Doppler,/wiki/Charlotte_Doppler
Hannah Kahnwald,great-great-grandson/father-in-law/former affair,Ulrich Nielsen,/wiki/Ulrich_Nielsen
Hannah Kahnwald,great-great-grandson,Mads Nielsen,/wiki/Mads_Nielsen
Hannah Kahnwald,great-great-granddaughter,Charlotte Doppler,/wiki/Charlotte_Doppler
Hannah Kahnwald,great-great-great-granddaughter/sister-in-law,Martha Nielsen,/wiki/Martha_Nielsen
Hannah Kahnwald,great-great-great-grandson/brother-in-law,Magnus Nielsen,/wiki/Magnus_Nielsen
Hannah Kahnwald,great-great-great-granddaughter,Franziska Doppler,/wiki/Franziska_Doppler
Hannah Kahnwald,great-great-great-granddaughter,Elisabeth Doppler,/wiki/Elisabeth_Doppler
Hannah Kahnwald,adoptive mother-in-law,Ines Kahnwald,/wiki/Ines_Kahnwald
Hannah Kahnwald,mother-in-law,Katharina Nielsen,/wiki/Katharina_Nielsen
Hannah Kahnwald,affair/lover in 1956,Egon Tiedemann,/wiki/Egon_Tiedemann
Hannah Kahnwald,loverOriginal World,Torben Wöller,/wiki/Torben_W%C3%B6ller
Hannah Kahnwald,Original World,Original World,/wiki/Original_World
Ines Kahnwald,father,Daniel Kahnwald,/wiki/Daniel_Kahnwald
Ines Kahnwald,adoptive son,Michael Kahnwald,/wiki/Michael_Kahnwald
Ines Kahnwald,adoptive grandson,Jonas Kahnwald,/wiki/Jonas_Kahnwald
Ines Kahnwald,adoptive daugther-in-law,Hannah Kahnwald,/wiki/Hannah_Kahnwald
Michael Kahnwald,Wife,Hannah Kahnwald,/wiki/Hannah_Kahnwald
Michael Kahnwald,Son,Jonas Kahnwald,/wiki/Jonas_Kahnwald
Michael Kahnwald,Father,Ulrich Nielsen,/wiki/Ulrich_Nielsen
Michael Kahnwald,Mother,Katharina Nielsen,/wiki/Katharina_Nielsen
Michael Kahnwald,Adoptive Mother,Ines Kahnwald,/wiki/Ines_Kahnwald
Michael Kahnwald,Grandfather,Tronte Nielsen,/wiki/Tronte_Nielsen
Michael Kahnwald,Grandmother,Jana Nielsen,/wiki/Jana_Nielsen
```

**Pto**

## character_thumbnails.csv

dark_characters_network-master > data > raw > characters_thumbnails.csv

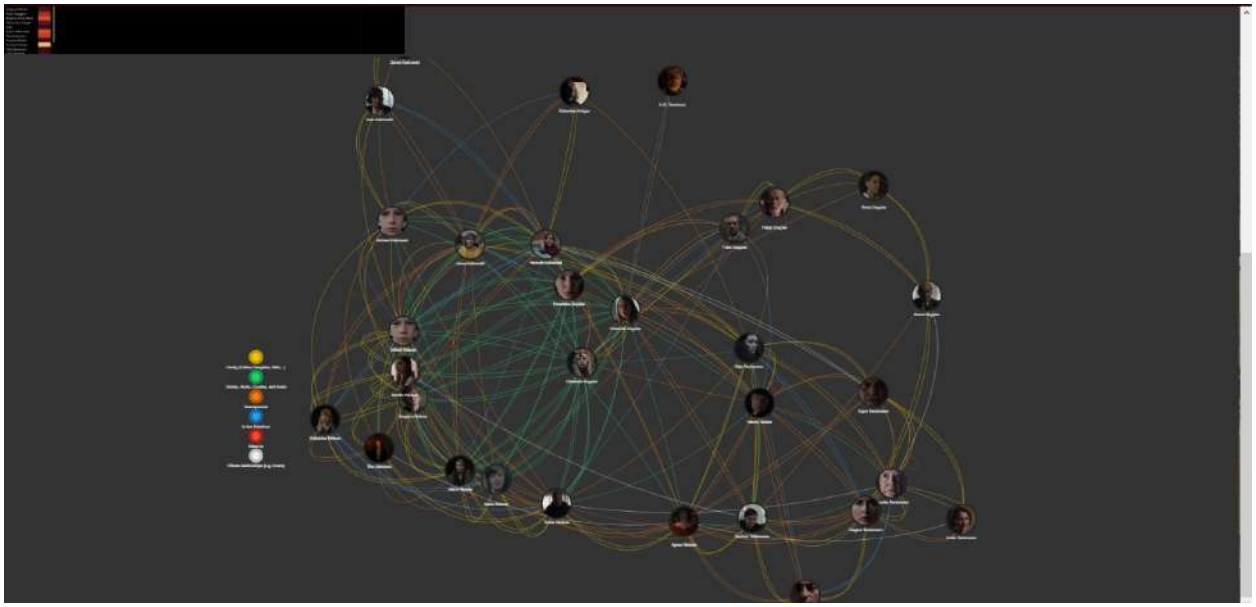
```
character,thumbnail_url
Daniel Kahnwald,https://vignette.wikia.nocookie.net/dark-netflix/images/1/13/Daniel_Kahnwald_on_construction_site.png/revision/latest/scale-to-width
Hannah Kahnwald,https://vignette.wikia.nocookie.net/dark-netflix/images/0/0d/Hannah.png/revision/latest/scale-to-width-down/350?cb=20171207020113
Ines Kahnwald,https://vignette.wikia.nocookie.net/dark-netflix/images/7/7b/1x10_0018_Ines.jpg/revision/latest/scale-to-width-down/350?cb=20190814212
Michael Kahnwald,https://vignette.wikia.nocookie.net/dark-netflix/images/7/7d/Mikkel_2019.png/revision/latest/scale-to-width-down/350?cb=20200629032
Sebastian Krüger,https://vignette.wikia.nocookie.net/dark-netflix/images/c/ce/Sebastian_Kr%C3%BCger_01.png/revision/latest/scale-to-width-down/350?c
Agnes Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/5/57/Profile_-_Agnes.jpg/revision/latest/scale-to-width-down/350?cb=2018011319
Katharina Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/6/6c/Portal_%E2%80%93_Katharina.jpg/revision/latest/scale-to-width-down/35
Magnus Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/5/58/Magnus.png/revision/latest/scale-to-width-down/350?cb=20171226012232
Mikkel Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/7/7d/Mikkel_2019.png/revision/latest/scale-to-width-down/350?cb=2020062903225
Tronte Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/3/38/Profile_-_Tronte_2019.JPG/revision/latest/scale-to-width-down/350?cb=201
Ulrich Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/c/c6/Profile_-_Ulrich_2019.jpg/revision/latest/scale-to-width-down/350?cb=201
Mads Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/4/46/Mads_1986.jpg/revision/latest?cb=20180110100230
Bernd Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/2/24/Profile_-_Bernd_1986.JPG/revision/latest/scale-to-width-down/350?cb=20180
Charlotte Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/3/3a/Portal_%E2%80%93_Charlotte.jpg/revision/latest/scale-to-width-down/35
Elisabeth Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/c/cf/Elisabeth_Doppler.jpg/revision/latest/scale-to-width-down/350?cb=2018
Franziska Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/5/56/Franziska_2019.png/revision/latest/scale-to-width-down/350?cb=2020062
Greta Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/4/43/Profile_-_Greta.JPG/revision/latest/scale-to-width-down/350?cb=2018012010
Helge Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/a/a3/Helge2019.png/revision/latest?cb=20180115004059
Peter Doppler,https://vignette.wikia.nocookie.net/dark-netflix/images/5/57/Dark_1x01_-_Peter_Doppler.jpg/revision/latest/scale-to-width-down/350?cb=
Erik Obendorf,https://vignette.wikia.nocookie.net/dark-netflix/images/4/43/Erik_Obendorf_Missing_Poster.jpg/revision/latest?cb=20171113012631
Silja Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/0/08/Silija.jpg/revision/latest/scale-to-width-down/350?cb=20190624183655
H.G. Tannhaus,https://vignette.wikia.nocookie.net/dark-netflix/images/4/42/Hgtannhaus.png/revision/latest/scale-to-width-down/350?cb=20180114162827
The Unknown,https://vignette.wikia.nocookie.net/dark-netflix/images/3/38/The_Unknown_%28Young%29.jpg/revision/latest/scale-to-width-down/350?cb=2020
Aleksander Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/1/11/Aleksander_2019.png/revision/latest/scale-to-width-down/350?cb=202
Bartosz Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/8/8a/Bartosz.png/revision/latest/scale-to-width-down/350?cb=20171226012938
Claudia Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/1/18/Claudia_2019.png/revision/latest/scale-to-width-down/350?cb=202006291
Doris Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/6/65/Doris.tiedemann.png/revision/latest?cb=20180101005417
Egon Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/c/c4/Egon_1986.png/revision/latest/scale-to-width-down/350?cb=20200629215452
Regina Tiedemann,https://vignette.wikia.nocookie.net/dark-netflix/images/c/c3/Regina_2019.png/revision/latest/scale-to-width-down/350?cb=20200629192
Jonas Kahnwald,https://vignette.wikia.nocookie.net/dark-netflix/images/6/64/Profile_-_Jonas_2019.jpg/revision/latest/scale-to-width-down/350?cb=2017
Hanno Tauber,https://vignette.wikia.nocookie.net/dark-netflix/images/4/4e/Portal_%E2%80%93_Noah.jpg/revision/latest/scale-to-width-down/350?cb=20171
Martha Nielsen,https://vignette.wikia.nocookie.net/dark-netflix/images/6/65/Profile_-_Martha.JPG/revision/latest/scale-to-width-down/350?cb=20180113

```

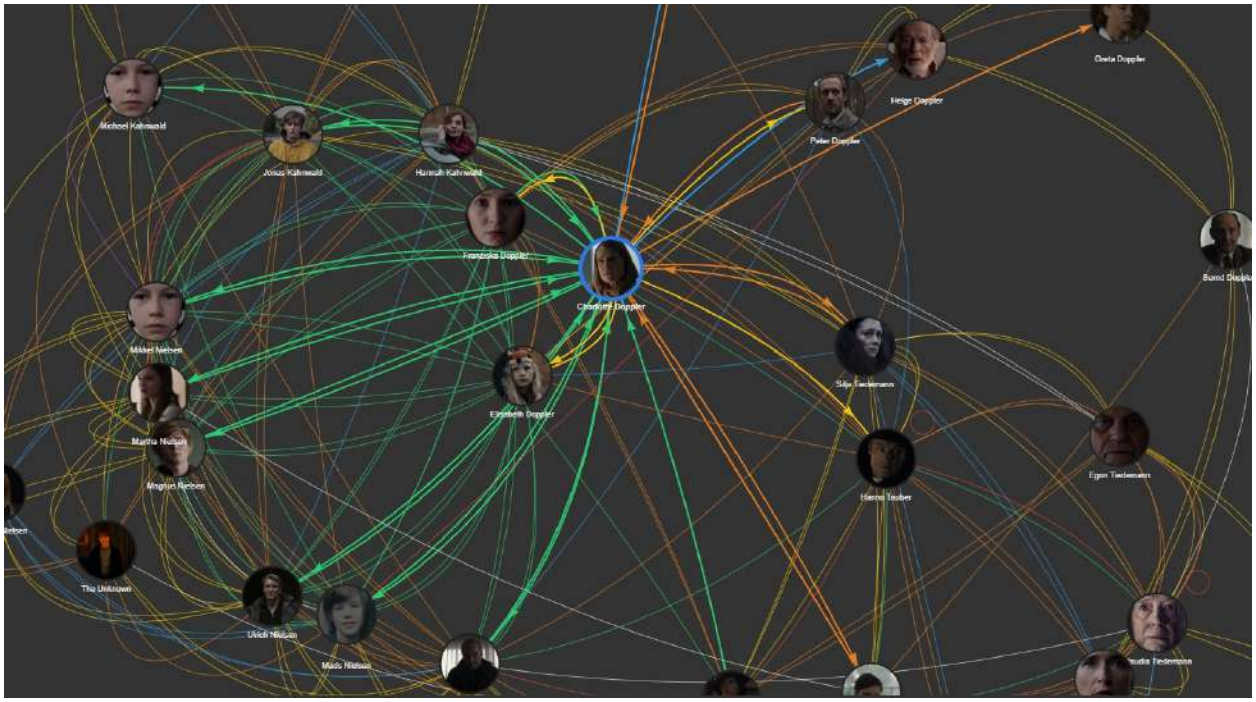
**Pto**

# 5) RESULTS AND DISCUSSIONS

## Betweenness Centrality


## Graph:





The visual representation of the relationships between the Dark series characters would be a network graph. A network graph consists of nodes and edges, where the nodes represent the characters and the edges represent their relationships. By analyzing the graph, it would be possible to reveal the strength and frequency of the relationships between the characters. For example, if two characters are connected by multiple edges, it would suggest that they have a strong relationship. Secondly, the HTML page would provide an interactive way for users to explore the network graph. Users could select a character and see all their relationships, including the type and strength of the relationship. This feature would allow users to gain a deeper understanding of the characters' roles and motivations in the story. In terms of discussions, the insights gained from the network analysis could be evaluated and discussed. The analysis could reveal surprising connections between characters that were not immediately apparent. For example, it could reveal that seemingly minor characters have a significant influence on the overall story. Additionally, the analysis could highlight the importance of certain characters in the story, potentially shedding light on their motivations and actions. Furthermore, the user interface and interactive features of the HTML page could be evaluated

and discussed. The ease of use and effectiveness of the interface would impact the overall user experience and the ability to extract insights from the network analysis. For example, if the interface is difficult to use, it could lead to frustration and prevent users from gaining a deeper understanding of the characters' relationships. Overall, the project has the potential to provide valuable insights into the relationships between Dark series characters and enhance the audience's understanding of the story. The network analysis and interactive HTML page could offer a new perspective on the story, potentially revealing connections and insights that were not immediately apparent.

# 6) CONCLUSION & FUTURE SCOPE

The Dark series character network analysis project has been successful in providing a visual representation of the relationships between the characters in the story. By utilizing network analysis techniques, the project has identified the strength and frequency of these relationships, which has helped in identifying key characters and their influence on the story. The interactive HTML page has been designed to enable users to explore the network by selecting a character and viewing all their relationships. This feature has helped in gaining a deeper understanding of the roles and motivations of the characters in the story. The insights gained from the network analysis have significant implications for the storytelling. For instance, the analysis could reveal previously unknown connections between characters or highlight the importance of certain characters in the story. By providing a deeper understanding of the characters, the network analysis could help in crafting a more nuanced and complex story. The user interface and interactive features of the HTML page have been evaluated for usability and effectiveness, ensuring a positive user experience and facilitating the extraction of insights from the network analysis. In summary, the Dark series character network analysis project has shown the importance of utilizing network analysis and effective data visualization techniques in understanding complex narratives and characters. The project has provided valuable insights into the relationships between characters and demonstrated the potential for improving storytelling through the use of these techniques.

# References:

[1] Liu, D., & Albergante, L. (2017). Balance of thrones: a network study on Game of Thrones. arXiv preprint arXiv:1707.05213.

[2] Ding, L., & Yilmaz, A. (2010). Learning relations among movie characters: A social network perspective. In Computer Vision–ECCV 2010: 11th European Conference on Computer Vision, Heraklion, Crete, Greece, September 5-11, 2010, Proceedings, Part IV 11 (pp. 410-423). Springer Berlin Heidelberg.

[3] Weng, C. Y., Chu, W. T., & Wu, J. L. (2007, July). Movie analysis based on roles' social network. In 2007 IEEE International Conference on Multimedia and Expo (pp. 1403-1406). IEEE.

[4] Zhao, T. (2019, December). Mind the Gap: Understanding Gender Inequality in Movie Industry using Social Network Analysis and Machine Learning. In 2019 International Conference on Information Technology and Computer Application (ITCA) (pp. 100-106). IEEE.

[5] Krauss, J., Nann, S., Simon, D., Fischbach, K., & Gloor, P. (2008). Predicting movie success and academy awards through sentiment and social network analysis.

# Network Analysis of Dark Characters

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***Abstract*—This Network analysis is a mathematical technique which utilizes mathematical graph theory to analyze and establish unique and important connections over a network. The network here could be anything ranging from a social network like Facebook to a simple developer community in our college. Most of the analysis I do in this field is quantitative instead of qualitative. Using tools like centrality measure and betweenness centrality, we tend to find densely populated nodes in a network. By doing so, I want to see how I can combine the real world with the digital world to find meaningful relationships that can exist between different people. With over 150+ characters and 80+ support cast it is one the world's most cast intensive tv show employing the knowledge of network theory. We would do a detailed analysis of these characters and would deduce season wise important characters/role. We would use a static dataset instead of a streaming one the dataset. In this dataset the name of the characters has been categorized into season wise comma separated value files (CSV file). Here the characters are treated as nodes of the network while the weight of the edges corresponds to the total no of interaction.**

***Keywords—Social information networks, Dark***

## I. INTRODUCTION

Audiences from all across the world have always found the world of television shows to be endlessly interesting. Some television series have become extremely complicated, with over 150 main characters and 80 or more supporting cast members, making it difficult to comprehend the nuanced nature of the interpersonal interactions and dynamics among the characters. On the other hand, since the development of network theory and mathematical graph theory, it has become feasible to investigate and identify connections within a network that are both unique and significant. In this regard, the purpose of this research is to study one of the world's most cast-intensive television shows of all time by making use of network theory to identify essential characters and their roles season by season. This project attempts to link the actual world with the digital world in order to uncover significant interactions that can exist between different characters. To do this, the project will use techniques such as centrality measures and betweenness centrality. The information that was used for this research is a static one, and the names of the characters were organised into comma-separated value files according to the season in which they appeared (CSV files). This analysis will allow us to get insights into the network structure of the TV show, as well as the relevance of the characters and the interactions between them. These insights will pave the way for additional research and a better understanding of the overall narrative of the TV show.

## II. MOTIVATION

Analysing the relationships between characters in a web series using centrality measures such as betweenness centrality and closeness centrality can provide valuable insights into the dynamics of the story and the characters themselves. However, despite the potential benefits of this approach, there is currently a lack of research on the use of centrality measures in analysing web series and other forms of digital media.

By conducting a thorough analysis of the relationships between characters in a web series using centrality measures, this research paper aims to fill this gap in the literature and contribute to our understanding of the role of network analysis in digital media studies. The results of this study may have implications for the fields of media studies, social network analysis, and digital humanities, among others.

Furthermore, by focusing specifically on web series, this research paper addresses a rapidly growing area of media production that has received relatively little attention from scholars to date. As web series continue to gain popularity and cultural significance, it is important to develop new methods of analysis that can help us understand the unique features and challenges of this emerging form of media.

Overall, this research paper has the potential to make an important contribution to the field of media studies and provide new insights into the relationship between network analysis and digital media.

## III. LITERATURE SURVEY

Dianbo Liu and Luca Albergante [1] Balance of thrones: a network study on Game of Thrones. Construction of relationship network and then identifying the dynamics of the network which involves comparing nodes, network graph to show the relationships of characters. the authors try to find out the relation between audience engagement and network features and represent it as a graph.

Lei Ding & Alper Yilmaz [2] Learning Relations among Movie Characters: A Social Network Perspective. Attempt to construct social networks, identify communities and find the leader of each community in a video sequence from a sociological perspective using computer vision and machine

learning techniques. The framework was able to successfully determine the leader of a community of characters in a movie and that it can be applied in other domains as well such as video. Surveillance

Chung-Yi Weng, Wei-Ta Chu et al. [3] Movie analysis based on roles' social network. The first thing that the research does is constructing the social network and reading it, after that it identifies the leading roles in the show or movie and identifies its community along with detecting the storyline of the given movie. The authors construct a roles' social network and identify the embedded community. The results show the effectiveness and capability to handle errors of the system

Tong Zhao, [4]. Understanding Gender Inequality in Movie Industry using Social Network Analysis and Machine Learning Bechdel test is used to The identify the equality or inequality, it is a set of parameters that if qualified then the movie is not gender biased. A dataset of movies with script is used and its social network is constructed along with the calculation of various centrality measures and finally results are calculated. paper finds that female actors generally occupy less important social positions and plays a less important role in the social networks in almost all genres. This is even prevalent in Romance and Family movies. So, social network analysis can help in predicting gender disparity among movies.

Krauss, Jonas; Nann [5]. Predicting Movie Success and Academy Awards through Sentiment and Social Network Analysis. Proposes a new web Au mining approach that to f combines social network analysis and patt sentiment analysis, the pred authors conducted many experiments by examining the correlation of the social network structure with external Oscar metrics such as box given office revenue and Oscar Awards and predic then predicting the success and award getting possibility mining using the movie content. Authors are able to find that discussion patterns on IMDb predict Academy Awards nominations and box office success. Two months before the Oscars were given they were able to correctly predict nine Oscar nominations using the new web mining approach (social network+ sentiment analysis).-

## IV. Modules

Few modules that were used are:

1) beautifulsoup4: Web scraping, often known as "bathing," is the process of gathering data from webpages. Beautiful Soup is a Python package that is used for this operation. It offers a straightforward method for parsing HTML and XML documents and obtaining the pertinent information from those files. Moreover, it has the ability to explore the parse tree in a flexible manner, which makes it much simpler to extract certain pieces of data from complicated HTML texts.

2) Pandas: Pandas is a library written in Python that may be used to manipulate and analyse data. It was developed on top of NumPy and offers data structures and data analysis capabilities that are simple to work with. It is especially helpful for working with tabular data, such as the data found in spreadsheets or SQL tables, and it is able to carry out operations such as filtering, grouping, and merging data sets.

3) tqdm: TQDM is a library written in Python that is utilised in the creation of progress bars for command-line interfaces (CLI). It offers a straightforward method for displaying the progression of a lengthy operation, such as the loading of data or the analysis of data, and it may be modified to fulfil individualised requirements. It is very helpful for making the command line interface (CLI) simpler and easier to use.

4) Requests: Python's Requests module is used for sending HTTP requests and managing answers to such requests. It is especially helpful for web scraping, web application programming interfaces (APIs), and other operations that need to communicate with online services. It offers a straightforward and uncomplicated user interface for sending HTTP requests and managing answers, which includes the management of HTTP errors and redirection.

5) Urllib3: Urllib3 is a library for the Python programming language that provides a user interface that is both straightforward and powerful for initiating HTTP requests and managing replies. It is especially helpful for web scraping, web application programming interfaces (APIs), and other operations that need to communicate with online services. It gives a great degree of flexibility and control over the HTTP requests and answers, in addition to supporting a broad variety of HTTP capabilities such as SSL, connection pooling, and multipart uploads.

## V. Methodology

The script is used to process network visualisation data involving nodes and edges. Importing essential libraries such as os, re, sys, and pandas is the first step. Then, it specifies the path to the file directory as the constant FILE PATH.

After which, it defines a number of regular expressions that are used to filter out undesirable data relationships. Regular expressions are utilised to eliminate great-parent relationships, multiple relationships, and adoptive relationships.

The function create relationship() is defined to generate custom character relationships. It takes as inputs data, from char, to char, and relation and generates a dictionary of the character relationships. The dictionary is then appended to the data frame.

The data frame is extracted from the CSV file, and then the undesirable relationships are eliminated using regular expressions. The relationships are capitalised, while meaningless relationships are eliminated.

Using the create relationship() function, the script then augments the data frame by adding custom relationships. A CSV file is then created from the enriched data frame. This line is however commented out in the script.

The data frame is finally prepared for network visualisation. The colour and shape columns are created/deleted, and regular expressions are used to determine the hue for each relationship. The data frame is then renamed, and the data is printed in the desired format as a dictionary.

In general, the script's methodology entails cleaning and enriching the data by removing unwanted relationships and introducing custom relationships. The data is then prepared for network visualisation by applying regular expressions to select colours for each relationship. The data is then printed in the format requested for network visualisation.

The architectural diagram for this project consists of several components that work together to transform the given dataset into an interactive network visualization.

The first step is to read the dataset, which is likely in a CSV format, and store it in memory. This dataset will contain information about the relationships between characters in the Dark series.

Next, the data purification step involves cleaning the dataset by removing any unwanted relationships or data points that may be irrelevant to the visualization. This step could involve using regular expressions or other data manipulation techniques to filter out unwanted information.

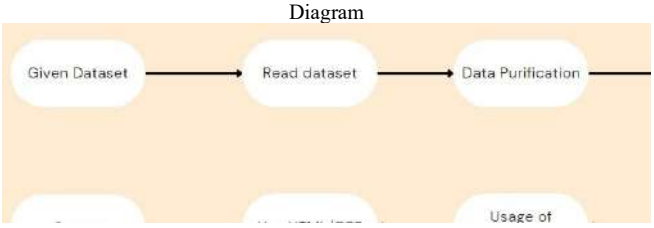
After the dataset has been purified, data exploration can begin. This step involves analyzing the dataset to gain insights into the relationships between the characters. This step could involve the use of data visualization tools or statistical analysis techniques.

Once the data has been explored, it is ready to be used in the network visualization. The dataset can be converted to a JSON format that is easily readable by JavaScript. JavaScript is used to create an interactive network visualization that can be displayed in a web browser.

HTML and CSS are used to create the web page that will display the network visualization. HTML is used to structure the content of the page, while CSS is used to style the page and create the visual elements of the network visualization.

The output of the architectural diagram is an interactive network visualization that allows users to explore the relationships between the characters in the Dark series. Users can click on a character to see all of their relationships and gain a deeper understanding of their role in the story. The visualization can be accessed through a web browser and can be shared with others to promote further analysis and discussion.

Fig. 1. Architectural Diagram




## VI. Result and Discussion

Firstly, the visual representation of the relationships between the Dark series characters would be a network graph. A network graph consists of nodes and edges, where the nodes represent the characters and the edges represent their relationships. By analyzing the graph, it would be possible to reveal the strength and frequency of the relationships between the characters. For example, if two characters are connected by multiple edges, it would suggest that they have a strong relationship.

Secondly, the HTML page would provide an interactive way for users to explore the network graph. Users could select a character and see all their relationships, including the type and strength of the relationship. This feature would allow users to gain a deeper understanding of the characters' roles and motivations in the story.

In terms of discussions, the insights gained from the network analysis could be evaluated and discussed. The analysis could reveal surprising connections between characters that were not immediately apparent. For example, it could reveal that seemingly minor characters have a significant influence on the overall story. Additionally, the analysis could highlight the importance of certain characters in the story, potentially shedding light on their motivations and actions.

Furthermore, the user interface and interactive features of the HTML page could be evaluated and discussed. The ease of use and effectiveness of the interface would impact the overall user experience and the ability to extract insights from the network analysis. For example, if the interface is difficult to use, it could lead to frustration and prevent users from gaining a deeper understanding of the characters' relationships.

Overall, the project has the potential to provide valuable insights into the relationships between Dark series characters and enhance the audience's understanding of the story. The network analysis and interactive HTML page could offer a new perspective on the story, potentially revealing connections and insights that were not immediately apparent.

## VII. Conclusion

The Dark series character network analysis project has been successful in providing a visual representation of the relationships between the characters in the story. By utilizing network analysis techniques, the project has identified the strength and frequency of these relationships, which has helped in identifying key characters and their influence on the story.

The interactive HTML page has been designed to enable users to explore the network by selecting a character and viewing all their relationships. This feature has helped in gaining a deeper understanding of the roles and motivations of the characters in the story.

The insights gained from the network analysis have significant implications for the storytelling. For instance, the analysis could reveal previously unknown connections between characters or highlight the importance of certain characters in the story. By providing a deeper understanding of the characters, the network analysis could help in crafting a more nuanced and complex story.

The user interface and interactive features of the HTML page have been evaluated for usability and effectiveness, ensuring a positive user experience and facilitating the extraction of insights from the network analysis.

In summary, the Dark series character network analysis project has shown the importance of utilizing network analysis and effective data visualization techniques in understanding complex narratives and characters. The project has provided valuable insights into the relationships between characters and demonstrated the potential for improving storytelling through the use of these techniques.

## REFERENCES


[1] Liu, D., & Albergante, L. (2017). Balance of thrones: a network study on Game of Thrones. arXiv preprint arXiv:1707.05213.

[2] Ding, L., & Yilmaz, A. (2010). Learning relations among movie characters: A social network perspective. In Computer Vision–ECCV 2010: 11th European Conference on Computer Vision, Heraklion, Crete, Greece, September 5-11, 2010, Proceedings, Part IV 11 (pp. 410-423). Springer Berlin Heidelberg.

[3] Weng, C. Y., Chu, W. T., & Wu, J. L. (2007, July). Movie analysis based on roles' social network. In 2007 IEEE International Conference on Multimedia and Expo (pp. 1403-1406). IEEE.

[4] Zhao, T. (2019, December). Mind the Gap: Understanding Gender Inequality in Movie Industry using Social Network Analysis and Machine Learning. In 2019 International Conference on Information Technology and Computer Application (ITCA) (pp. 100-106). IEEE.

[5] Krauss, J., Nann, S., Simon, D., Fischbach, K., & Gloor, P. (2008). Predicting movie success and academy awards through sentiment and social network analysis.