*Ontology of Film-production*

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*Abstract*— *While film-making may seem like a simple process to the average viewer, the process involved in the creation of films is rather expansive. The use of an ontology to model the film-making process is a useful and very helpful tool that can assist film-makers in their endeavours to create the best possible film without encountering unexpected hurdles.*

*Oftentimes when it comes to film-making, the production team may skip important details in regards to the correct way in approaching the task at hand. This is due to a lack of knowledge or experience in the industry.*

*A standardized framework for new and experienced producers to use would be beneficial. The standardized ontology will allow for the integration of film data and easier interoperability of applications that use this data such as IMDB and Netflix.*

*Once in place a standardized film ontology can be further expanded on to include new technologies in the film industry and will be the foundation of development for other applications. This will hopefully also lead to easier data mapping i.e. direct mapping from data sources to the ontology so that newcomers can easily access data from multiple sources through the ontology. This will result in decreased volumes of repeated data and decreased costs and effort.*

*The study will use the ontology development 101 methodology, which is the a commonly used standard.*

*Data has been collected by researching the film-making process to find out exactly what goes on behind the scenes. Websites and articles were used in order to understand the process clearly.*

Keywords— Film-Making, Ontology, Data, Framework, Interoperability

# Introduction & Overview

Movies are an excellent source of entertainment and mostly take somewhere between 90 minutes to 120 minutes to watch. Some movies are forgotten shortly after and some become instant classics. However, even the shortest of movies can take months, if not years to create. There are multiple parts to the domain which include the initial development, preproduction, shooting and post production [1].

In this study, the concepts used for film-production, as well as each component and their relationships, are put into an ontology to represent the entire domain in a way that makes it easier to process. The use of an ontology would allow for a common understanding of film-making Information modelled by this knowledge base would allow for reusability, would make assumptions within the domain explicit and could be used to analyse the domain knowledge[20]. An important upside to using an ontologically based model is that it can always be extended in order to evolve along with the evolution of processes involved in this field.

The Ontology Development 101 Methodology is used to create the ontology [3]. This methodology is broken up into 7 steps that assist in the creation of ontologies. Throughout this methodology, steps such as asking questions, reusing existing ontologies and identifying classes and their hierarchy are followed. The entire process is explained in the next section.

By looking at an overview of film-production [1], it was possible to get an idea of what it entails. This led to different aspects that domain is split up into, including the crew [5], Distribution Techniques, budgets[11], and costs[12]. Each aspect was looked into to find what resources would be spent on.

The aim of the study is to create an ontology that will provide current and future film-makers with a knowledge-base and comprehensive model to use as a base- and guideline to create films. It also aims to create a standardized model for the querying and use of data in the domain.

The film industry has become significantly inspired by data. This increased focus emphasizes the need to bridge the gap between differing data sources and the disjoint data depository which populate the entertainment databases[18]. This is done via machine-to-machine format which presents a possible substantial decrease in time as well as the resources which are committed to and required for the integration of data of several sources which are necessary to the success of the industry [2]. An example of this would be a Netflix or Amazon Prime querying the ontology to gather and display information about scenes in a Film such as who the director is and be able to expand into his other works.

Overview of film-production

Every film starts with an idea. Ideas can stem from many sources, which may be newspapers, books, plays or even conversations. In most cases, producers get an idea, directors visualise it and writers clarify it.

Next is to get the development finance. This can be gathered through multiple different means, such as tax incentives, crowd funding and private source funding, amongst others. The producer tries to obtain the funding required.

Once funding is taken care of, the script is written. The writer produces a synopsis highlighting the key events in the film. The writer then plans the scripts and creates the first draft. Once revisions have been made, the producer signs off on it and it is sent to the financiers to approve. The final draft of the script is then made. After this the film is commercially proposed, famous actors or lead actors are approached as well experienced head of departments. This is done for the film to gain more traction and attention. The film is then turned into a business proposition where the producer must plan a basic cost assessment for each phase of the process. This is done so that investors can know how much they will need to invest and what their expected returns will be. Production funding is then required, and this can be attained through the same means as development funding with the additions of pre-sales, completion bonds and studio funding. Once a film has the budget green light it can begin pre-production which is where the cast is hired, and the actors begin to be cast. Pre-production also includes storyboarding (where each scene is planned and discussed) and the production design is complete (planning how each aspect of the film will look and hiring the crew for it). The next step is the Shooting phase which starts with photography. The camera crew then shoot the scenes with the actors and lighting + sound crews. Special effects are then added. Each scene must adhere to a tight schedule. The film then goes through postproduction i.e. editing, mixing, and cutting of the scenes to create one whole film. A trailer is then made and distributed to advertise the film and then the film is taken to market. The director will negotiate with distributors such as festivals, international cinemas, or online streaming services.  To increase viewership the film must be marketed, and this is done through advertising such as movie posters, online campaigns etc. The film will then be premiered which can be done through film festivals, big budget releases, Streaming platforms etc. [1]

In a nutshell, what was gathered from looking at various ontologies, papers and articles was that the domain is rather vast. There are multiple subdomains that deal with the people involved in the creation of films, the attributes that make a film unique, such as props, sets and locations, as well as the financial side of it which includes funding and budgets.

# Literature review

The creation of this ontology stands to provide a standardised framework for film-making. The movie industry is moving towards being a highly data-driven field[18]. Data management systems are being built, by technologists, that require assumptions about entities, properties and relationships. Industry standards are used and adopted from when possible and new data frameworks are created when necessary[18]. [18] explains how lack of information sharing in the film industry leads to interoperability amongst the role players in the domain. It is an extremely in-depth paper that talks about every step of the data exchange process when movies are made and how this data could benefit from being used and stored via an ontology. It explains how data mappings and ontologies can aid in creation of shared industry repositories.

 A variety of different literature, which includes articles, research papers, as well as existing ontologies were used to create a knowledge base that can be used and expanded upon in future.

Looking at the work done by Motion Picture Laboratories[18], it was found that the movie knowledge base is rather vast. Their ontology provides an overview of what a movie comprises of, including a multitude of properties and fields. This work was used as a core for the creation of the [[Movie]] ontology. This ontology provides a comprehensive foundation that could be used to expand on this topic.

[2] provides an ontology that models the core of film production and the workflows used at different stages of production that they have broken into three parts. By looking at the core of film production, it is possible to derive the concepts that should be included in the film-making knowledge base.

The first stage that was modelled is the preproduction which covers concepts regarding the planning of production and what is used to record their creative ideas. For instance, directors use paper-based scripts and storyboards to plan shots that are used to create the film. They have consulted with film-makers and analysed existing works to identify the main elements of a movie script and their relationships with one another.

The OntoFilm ontology that they have created models the data they have found by showing the main elements such as Scene, Shot , Character and Dialogue and how they relate to each other. The second stage expands on the on-set production model.

It was found that directors often follow a set of filming conventions in the shoot of a scene. They have conceptualized these ‘rules’ with what they call *Film Grammar* concepts. Those of wish include the ‘180 Degree Rule’ and the ‘3 Degree Rule’. Their on-set production model also includes a Director Notation ontology which is used to describe scenes during shooting. Following this, they have created a post-production model.

The focus of this model is the workflow that is involved. It covers important concepts relating to assembling the film from the various shots taken and how they are processed post production. These concepts are linked to the technical descriptions of media involved as well as to scene descriptions from the On-Set Production model. This allows for a unified semantic representation of the shot portrayed on screen as well as the actors, props, locations and the rationale for creating the scene. Based on the OntoFilm paper, it was possible to gain insight to the knowledge base required for film-making.

From looking at the film-production process that was modelled in this paper, there were concepts and actors that stood out to be used in the creation of a knowledge base required for film-making. The actions of team members in this provides an insight on their relationships to one-another, what they achieve in their roles and how they relate to the concepts that are provided in this paper.

Looking further into the Internet Movie Database(IMDb), the work of S. Avancha, S. Kallurkar and T. Kamdar[19] outlines important information about movies. The IMDb paper shows us how the database is constructed and how different attributes of movies are used to create the final product.

The paper describes the shortfalls of the IMDB database and how it could benefit from an ontological approach. It describes how an ontology makes the sharing and searching of data easier and helps us understand how a film ontology can be practically applied to concepts that currently exist. They give us a good idea of how classes and relationships interact and use an example query to show us how information sharing increases when using an ontology.

They conclude that an ontology will scale the information in the current database as it gives a set format in which a Prolog engine can read new submissions of data and update the database. A shortfall of this paper is that it has limited instances and properties. This lead to an unfinished ontology, it was however very helpful with understanding the core need for an ontology and how it can aid automated processing.

[11] and [12] speak about the budgeting and financing of a film. They speak about each step of production process and what costs are involved. The also cover how Companies would attain funding. We used these articles to help model our classes for budgeting and finance.

[9] covers ontology design patterns. This does not relate directly to film making but it helped in designing our ontology and what methods to follow. It speaks about best practices and reusable modelling solutions which helped us with the direction of our ontology i.e. what the end goal was and what we should include in order to achieve a standardized and query friendly ontology.

[20] is the Protégé Development guide from Stanford university. It covers in depth the steps to develop an ontology on protégé, although it is very detailed it is outdate so this was used in conjunction with the protégé documentation to create the Ontology on protégé. The portion on deciding whether a entity is an instance or a class was extremely important as it helped us rework our ontology to include only the most important things as classes(sub-classes)

[15] talks about the use of ontologies with regards to information retrieval and knowledge modelling. These are both very important concepts for our ontology as the main purpose is information retrieval. It speaks about semantic relationships between data, interactive querying through ontologies and processing of domain knowledge. These were very important concepts in helping us understand what a film ontologies main purpose would be and how to best represent that through our ontology.

# Materials and methods

## Methodology

The Ontology Development 101 Methodology is used to create this ontology[3]. This methodology is broken up into various steps that should be followed in sequence.

**Step One**: Determine the domain and scope of the ontology. This is done by posing several questions such as:

What domain is covered by the ontology?

What is the ontology used for?

What questions will the ontology answer?

Who will the ontology be used and maintained by?

**Step Two**: Reuse Existing Ontologies; by Researching existing Ontologies we gain understanding of the topic and can use those ontologies to extend our list of sources. This can also reduce the amount of time spent making the ontology.

**Step Three**: Create a Lexicon of Words and Terms that will be used in the ontology

**Step Four**: Identify classes and their hierarchy i.e. in the top down approach which we are using, we create general classes such a crew and funding and then look into the subclasses of them.

**Step Five**: Identify the properties of the classes

**Step Six**:  Decide on the allowed values, the cardinalities, value type as well as the domain and ranges.

**Step Seven**: Identify instances of the classes being used ie the individuals.

## Data Collection

* The focus of this paper is to create a standardised ontology for Film Making, most of our data comes from the Creative Works Ontology [18]. From this ontology we used their basic structure and terms with specific focus on Film Making (as opposed to Television Series and Awards). The IMDB Ontology [19] focuses more on the Film (i.e. it does not include external terms such as Costs, Equipment etc) itself and from that we were able to combine terms and structures with [18] to create a more streamlined Ontology that focused specifically on Film production. From website article [1] we learnt about the film-making process and the different stages of film production including the members included at each step, although we aren’t modelling a process it helped us understand what needs to be done when Filming a movie so as to better understand what we need to include and represent in our ontology. [5] tells us about each Crew Member in the film and what their job entails. It is important to know as it helps us relate equipment to members and helps us model other relationships within the ontology.

## Formalization of Ontology

We will be using three logical languages: Description Logic (DL), First Order Logic(FOL) and Web Ontology Language(OWL).  DLs provide means to model relationships between concepts, roles and individuals in order to formalize a domain. FOLs use objects, relations and functions to represent an ontology. OWL is a mark-up language used to make and share ontologies in a formalized and standardized manner.

# Modeling of Ontology

## Vocabulary of the Domain

Competency questions:

1. What is the film based on?
2. How is a film budgeted?
3. How are films promoted?
4. What equipment is needed to make a film?
5. Where does funding come from to make a movie?
6. What crew is required?
7. What is used to create the set?
8. How will the movie be distributed?
9. What are the Genres of a Movie?
10. What does the crew need to do?
11. Can the ontology be used to display information about the film?
12. Can the ontology be used to display information about the crew?
13. Can the ontology be used to display information about the equipment used?

Classes:

Film, Story, Movie\_Idea, Script, Budget, Promotion\_Technique, Equipment, Funding, Set\_Material, Set, Distribution\_Technique, Genre, Crew\_Member, Scene, Location, Costume, Storyboard, Award, Presentation, Country, Restriction, Ranking, Video\_Game, True\_Story, Comic\_Book, Original\_Idea, Another\_Film, Play, Book, Marketing\_Budget, Film\_Budget, Sound\_Equipment, Lighting\_Equipment, Camera\_Equipment, Colour\_Info, Language, Stunt\_Crew, Actor, Casting\_Director, Storyboard\_Artist, Film\_Editor, Costume\_Designer, VFX\_Supervisor, Hairdress, Makeup\_Artist, Lighting\_Technician, Gaffer, Construction\_Crew, Buyer, Set\_Designer, Boom\_Operator, Production\_Sound\_Mixer, Location\_Scout, Location\_Manager, Camera\_Operator, Cinematographer, Stunt\_Co-ordinator, Script\_Editor, Story\_Producer, Production\_Co-ordinator, Line\_Producer, Executive\_Producer, Screenwriter, Director, Producer

Instances:

BAFTA\_Film\_Award, Golden\_Globe\_Award, Oscar\_Award, Black\_and\_White, Colour, English, Spanish, , Age\_Restriction, Content\_Restriction, Action\_Genre, Comedy\_Genre, Crime\_Genre, Drama\_Genre, Fantasy\_genre, Historical\_Genre, Horror\_Genre, Mystery\_Genre, Political\_Genre, Romance\_Genre, Thriller\_Genre, Festival\_Release, Streaming\_Release, Theatrical\_Release, Backdrop, Carpentry, Flooring, Lighting, Prop, Scenery\_Wagon, Crowd\_Funding, Government\_Grant, Pre\_Sales, Private\_Source, Studio\_Funding, Tax\_Incentive, Clapperboard, Screenwriting\_Software, Storyboard\_Maker, Boom\_Pole, Microphone, Light, Light\_Meter, Camera, Lens, Tripod, Cinema\_Trailer, Movie\_Poster, Online\_Advertisment, Third\_Party, Cast\_Cost, Completion\_Bond, Director\_Cost, Insurance, Post\_Production\_Cost, Producer\_Cost, Production\_Cost, Production\_Staff\_Cost, Screenplay\_Cost, Story\_Rights\_Cost, Tomb\_Raider, The\_Long\_Walk\_To\_Freedom, Batman\_:\_The\_Dark\_Knight, Lion\_King, Hamlet, Harry\_Potter\_and\_the\_Philospher's\_Stone

Relations:

hasStory, isBasedOn, depictsStory, hasMonetary, utilizes, isFinancedBy, createdFrom, distributedBy, belongsTo, isPartOf, supervisesProduction, managesCreativeAspectOf, invests, oversees, createsScript, createsStory, revises, supervisesStuntsOf, framesShots, captures, managesLogistics, searchesFor, managesSoundEngineeringOf, operates, designsLayout, purchases, builds, constructs, setsUpElectricalComponentsFor, setsUpLightingForm, performsMakeUpOperationsOn, performStylingOperationsOn, coordinatesVisualEffectsOf, designsStyleOf, assembles, makes, casts, actsIn, hires, rents, filmIsAwardedWith, actorisAwardedWith, madeUp, shotAt, hasSet, hasLocation, hasReleasingCountry, hasRanking, hasRestriction, enactedIn, enacts, inScene

## List of Axioms of the Domain

|  |  |
| --- | --- |
|  | Film has a Story |
|  | Story is based on Movie\_Idea |
|  | Script depicts a Story |
|  | Book is a type of Movie\_Idea |
|  | Harry\_Potter\_and\_the\_Philosopher's\_Stone is an instance of a Book |
|  | Play is a type of Movie\_Idea |
|  | Hamlet is an instance of a Play |
|  | Another\_Film is a type of Movie\_Idea |
|  | Another\_Film is an instance of Lion\_King |
|  | True\_Story is a type of Movie\_Idea |
|  | The\_Long\_Walk\_To\_Freedom is an instance of True\_Story |
|  | Video\_Game is a type of Movie\_Idea |
|  | Tomb\_Raider is an instance of Video\_Game |
|  | Comic\_Book is type of Movie\_Idea |
|  | Batman\_:\_The\_Dark\_Knight is an instance of Comic\_Book |
|  | Original\_Idea is a type of Movie\_Idea |
|  | Film is awarded with Award |
|  | Actor is awarded with Award |
|  | BAFTA\_Film\_Award is instance of Award |
|  | Golden\_Globe\_Award is instance of Award |
|  | Oscar\_Award is instance of Award |
|  | Film is made up of several Scene |
|  | Each Scene is shot as some Location |
|  | Each Scene has at least one Set |
|  | Each Set has a Location |
|  | Colour\_Info is a type of Presentation |
|  | Black\_and\_White is an instance of Colour\_Info |
|  | Colour is an instance of Colour\_Info |
|  | Language is a type of Presentation |
|  | English is an instance of a Language |
|  | Spanish is an instance of a Language |
|  | Film has releasing country Country |
|  | Film has Ranking |
|  | Film has Restriction |
|  | Content\_Restriction is an instance of Restriction |
|  | Age\_Restriction is an instance of Restriction |
|  | Script is enacted in Scene |
|  | Actor enacts the Script in some Scene |
|  | Film has a monetary Budget. |
|  | Film\_Budget is type of Budget |
|  | Marketing\_Budget is type of Budget |
|  | Story\_Rights\_Cost is an instance of Film\_Budget |
|  | Screenplay\_Cost is an instance of Film\_Budget |
|  | Cast\_Cost is an instance of Film\_Budget |
|  | Producer\_Cost is an instance of Film\_Budget |
|  | Director\_Cost is an instance of Film\_Budget |
|  | Production\_Cost is an instance of Film\_Budget |
|  | Production\_Staff\_Cost is an instance of Film\_Budget |
|  | Post\_Production\_Cost is an instance of Film\_Budget |
|  | Insurance is an instance of Film\_Budget |
|  | Completion\_Bond is an instance of Film\_Budget |
|  | Third-party is an instance of Marketing\_Budget |
|  | Film is marketed by Promotion\_Techniques |
|  | Cinema\_Trailer is an instance of Promotion\_Technique |
|  | Movie\_Poster is an instance of Promotion\_Technique |
|  | Online\_Advertisment is an instance of Promotion\_Technique |
|  | Crew\_Member utilizes the Equipment |
|  | Camera\_Equipment is-a type of Equipment |
|  | Lighting\_Equipment is-a type of Equipment |
|  | Sound\_Equipment is-a type of Equipment |
|  | Screenwriting\_Software is an instance of Equipment |
|  | Clapperboard is an instance of Equipment |
|  | Storyboard\_Maker is an instance of Equipment |
|  | Camera is an instance of Camera\_Equipment |
|  | Lens is an instance of Camera\_Equipment |
|  | Tripod is an instance of Camera\_Equipment |
|  | Light\_Meter is an instance of Lighting\_Equipment |
|  | Light is an instance of Lighting\_Equipment |
|  | Microphone is an instance of Sound\_Equipment |
|  | Boom\_Pole is an instance of Sound\_Equipment |
|  | Film is financed by Funding |
|  | Government\_Grant is an instance of Funding |
|  | Tax\_Incentive is an instance of Funding |
|  | Private\_Source is an instance of Funding |
|  | Crowd\_Funding is an instance of Funding |
|  | Studio\_Funding is an instance of Funding |
|  | Pre\_Sales is an instance of Funding |
|  | Set is created from Set\_Material |
|  | Backdrop is an instance of Set\_Material |
|  | Scenery is an instance of Set\_Material |
|  | Prop is an instance of Set\_Material |
|  | Flooring is an instance of Set\_Material |
|  | Lighting is an instance of Set\_Material |
|  | Scenery\_Wagon is an instance of Set\_Material |
|  | Carpentry is an instance of Set\_Material |
|  | Film is distributed by some Distribution\_Technique after production |
|  | Theatrical\_Release is an instance of Distribution\_Technique |
|  | Streaming\_Release is an instance of Distribution\_Technique |
|  | Festival\_Release is an instance of Distribution\_Technique |
|  | Film belongs to atleast one Genre |
|  | Action\_Genre is an instance of Genre |
|  | Comedy\_Genre is an instance of Genre |
|  | Crime\_Genre is an instance of Genre |
|  | Drama\_Genre is an instance of Genre |
|  | Fantasy\_Genre is an instance of Genre |
|  | Historical\_Genre is an instance of Genre |
|  | Horror\_Genre is an instance of Genre |
|  | Mystery\_Genre is an instance of Genre |
|  | Political\_Genre is an instance of Genre |
|  | Romance\_Genre is an instance of Genre |
|  | Thriller\_Genre is an instance of Genre |
|  | Producer is part of Crew |
|  | Director is part of Crew |
|  | Screenwriter is part of Crew |
|  | Executive\_Producer is part of Crew |
|  | Line\_Producer is part of Crew |
|  | Production\_Co-ordinator is part of Crew |
|  | Story\_Producer is part of Crew |
|  | Script\_Editor is part of Crew |
|  | Stunt\_Co-ordinator is part of Crew |
|  | Cinematographer is part of Crew |
|  | Camera\_Operator is part of Crew |
|  | Location\_Manager is part of Crew |
|  | Location\_Scout is part of Crew |
|  | Production\_Sound\_Mixer is part of Crew |
|  | Boom\_Operator is part of Crew |
|  | Set\_Designer is part of Crew |
|  | Buyer is part of Crew |
|  | Construction\_Crew is part of Crew |
|  | Gaffer is part of Crew |
|  | Lighting\_Technician is part of Crew |
|  | Makeup\_Artist is part of Crew |
|  | Hairdresser is part of Crew |
|  | VFX\_Supervisor is part of Crew |
|  | Costume\_Designer is part of Crew |
|  | Costume\_Supervisor is part of Crew |
|  | Film\_Editor is part of Crew |
|  | Storyboard\_Artist is part of Crew |
|  | Casting\_Director is part of Crew |
|  | Actor is part of Crew |
|  | Producer supervises production of Film |
|  | Director manages creative aspect of Film |
|  | Screenwriter creates Script |
|  | Executive\_Producer invests in Film |
|  | Line\_Producer oversees Budget |
|  | Production\_Co-ordinator hires Crew\_Members and rent Equipment |
|  | Story\_Producer creates Story |
|  | Script\_Editor revises Script |
|  | Stunt\_Co-ordinator supervises stunts of Stunt\_Crew |
|  | Cinematographer frames shots for a Scene |
|  | Camera\_Operator captures Scene |
|  | Location\_Manager manages logistics of Location |
|  | Location\_Scout searches for Location |
|  | Production\_Sound\_Mixer manages sound engineering of the Film |
|  | Boom\_Operator operates Sound\_Equipment |
|  | Set\_Designer designs layout of Set |
|  | Buyer purchases Set\_Material |
|  | Construction\_Crew constructs Set |
|  | Gaffer sets up electrical components for a Scene |
|  | Lighting\_Technician sets up lighting for a Scene |
|  | Makeup\_Artist performs makeup operations on Actor |
|  | Hairdresser performs styling operations on Actor |
|  | VFX\_Supervisor coordinates visual effects of Film |
|  | Costume\_Designer designs style of Costume |
|  | Film\_Editor assembles and edits Film |
|  | Storyboard\_Artist makes Storyboard |
|  | Casting\_Director casts Actor |
|  | Actor acts in Film |

## FOL Represenation of the Domain

|  |  |
| --- | --- |
|  | ∀x (Film(x) → ∃y hasStory (x, y) ∧ Story(y)) |
|  | ∀x (Story(x) → ∃y (isBasedOn (x, y) ∧ Movie\_Idea(y)) |
|  | ∀x (Script(x) → ∃y depictsStory (x, y) ∧ Story(y)) |
|  | ∀x (Book(x)→ Movie\_Idea(x)) |
|  | Book (Harry\_Potter\_and\_the\_Philosopher's\_Stone) |
|  | ∀x (Play(x)→ Movie\_Idea (x)) |
|  | Play (Hamlet) |
|  | ∀x (Another\_Film(x)→ Movie\_Idea (x)) |
|  | Another\_Film (Lion\_King) |
|  | ∀x (True\_Story(x)→ Movie\_Idea (x)) |
|  | True\_Story (The\_Long\_Walk\_To\_Freedom) |
|  | ∀x (Video\_Game(x)→ Movie\_Idea (x)) |
|  | Video\_Game (Tomb\_Raider) |
|  | ∀x (Comic\_Book(x)→ Movie\_Idea (x)) |
|  | Comic\_Book (Batman\_:\_The\_Dark\_Knight) |
|  | ∀x (Original\_Idea (x)→ Movie\_Idea (x)) |
|  | ∀x (Film(x) → ∃y (filmIsAwardedWith (x, y) ∧ Award(y)) |
|  | ∀x (Actor(x) → ∃y (actorIsAwardedWith (x, y) ∧ Award(y)) |
|  | Award (BAFTA\_Film\_Award) |
|  | Award (Golden\_Globe\_Award) |
|  | Award (Oscar\_Award) |
|  | ∀x (Film(x) → ∃y (madeUp (x, y) ∧ Scene(y)) |
|  | ∀x (Scene(x) → ∃y (shotAtLocation (x, y) ∧ Location(y)) |
|  | ∀x (Scene(x) → ∃y (hasSet (x, y) ∧ Set(y)) |
|  | ∀x (Set(x) → ∃y (hasLocation (x, y) ∧ Location(y)) |
|  | ∀x (Colour\_Info(x) → Presentation(x)) |
|  | Colour\_Info (Black\_and\_White) |
|  | Colour\_Info (Colour) |
|  | ∀x (Language(x) → Presentation(x)) |
|  | Language (English) |
|  | Language (Spanish) |
|  | ∀x (Film(x) → ∃y (hasReleasingCountry (x, y) ∧ Country(y)) |
|  | ∀x (Film(x) → ∃y (hasRanking (x, y) ∧ Ranking(y)) |
|  | ∀x (Film(x) → ∃y (hasRestriction (x, y) ∧ Restriction(y)) |
|  | Restriction (Content\_Restriction) |
|  | Restriction (Age\_Restriction) |
|  | ∀x (Script(x) → ∃y (enactedIn (x, y) ∧ Scene(y)) |
|  | ∀x (Actor(x) → ∃y, z (enacts (x, y) ∧ inScene (x, z) Script (y) ∧ Scene(z)) |
|  | ∀x (Film (x)→∃y hasMonetary (x, y) ∧ Budget(x)) |
|  | ∀x (Film\_Budget(x)→ Budget(x)) |
|  | ∀x (Marketing\_Budget(x)→ Budget(x)) |
|  | Film\_Budget (Story\_Rights\_Cost) |
|  | Film\_Budget (Screenplay\_Cost) |
|  | Film\_Budget (Cast\_Cost) |
|  | Film\_Budget (Producer\_Cost) |
|  | Film\_Budget (Director\_Cost) |
|  | Film\_Budget (Production\_Cost) |
|  | Film\_Budget (Production\_Staff\_Cost) |
|  | Film\_Budget (Post\_Production\_Cost) |
|  | Film\_Budget (Insurance) |
|  | Film\_Budget (Completion\_Bond) |
|  | Marketing\_Budget (Third\_Party) |
|  | ∀x (Film(x) → ∃y (isMarketedBy (x, y) ∧ Promotion\_Technique(y)) |
|  | Promotion\_Technique (Cinema\_Trailer) |
|  | Promotion\_Technique (Movie\_Poster) |
|  | Promotion\_Technique (Online\_Advertisment) |
|  | ∀x (Crew\_Member(x) → ∃y (utilizes (x, y) ∧ Equipment(y)) |
|  | ∀x (Camera\_Equipement(x)→Equipment(x)) |
|  | ∀x (Lighting\_Equipement(x)→Equipment(x)) |
|  | ∀x (Sound\_Equipement(x)→Equipment(x)) |
|  | Equipment (Screenwriting\_Software) |
|  | Equipment (Clapperboard) |
|  | Equipment (Storyboard\_Maker) |
|  | Camera\_ Equipment (Camera) |
|  | Camera\_ Equipment (Lens) |
|  | Camera\_ Equipment (Tripod) |
|  | Lighting\_Equipment (Light\_Meter) |
|  | Lighting\_Equipment (Light) |
|  | Sound\_Equipment (Microphone) |
|  | Sound\_Equipment (Boom\_Pole) |
|  | ∀x (Film(x) → ∃y (isFinancedBy(x, y) ∧ Funding(y)) |
|  | Funding (Government\_Grant) |
|  | Funding (Tax\_Incentive) |
|  | Funding (Private\_Source) |
|  | Funding (Crowd\_Funding) |
|  | Funding (Studio\_Financing) |
|  | Funding (Pre\_Sales) |
|  | ∀x (Set(x) → ∃y, createdFrom(x, y) Λ Set\_Material(y)) |
|  | Set\_Material (Backdrop) |
|  | Set\_Material (Scenery) |
|  | Set\_Material (Prop) |
|  | Set\_Material (Flooring) |
|  | Set\_Material (Lighting) |
|  | Set\_Material (Scenery\_Wagon) |
|  | Set\_Material(Carpentry) |
|  | ∀x (Film(x) ∧ produced(x) → ∃y (distributedBy (x, y) ∧ Distribution\_Technique(y)) |
|  | Distribution\_Technique (Theatrical\_Release) |
|  | Distribution\_Technique (Streaming\_Release) |
|  | Distribution\_Technique (Festival\_Release) |
|  | ∀x (Film(x) → ∃y belongsTo (x, y) ∧ Genre(y)) |
|  | Genre (Action\_Genre) |
|  | Genre (Comedy\_Genre) |
|  | Genre (Crime\_Genre) |
|  | Genre (Drama\_Genre) |
|  | Genre (Fantasy\_Genre) |
|  | Genre (Historical\_Genre) |
|  | Genre (Horror\_Genre) |
|  | Genre (Mystery\_Genre) |
|  | Genre (Political\_Genre) |
|  | Genre (Romance\_Genre) |
|  | Genre (Thriller\_Genre) |
|  | ∀x Producer (x) → Crew\_Member(x) |
|  | ∀x Director (x) → Crew\_Member(x) |
|  | ∀x Screenwriter (x) → Crew\_Member(x) |
|  | ∀x Executive\_Producer (x) → Crew\_Member(x) |
|  | ∀x Line\_Producer (x) → Crew\_Member(x) |
|  | ∀x Production\_Co-ordinator (x) → Crew\_Member(x) |
|  | ∀x Story\_Producer (x) → Crew\_Member(x) |
|  | ∀x Script\_Editor (x) → Crew\_Member(x) |
|  | ∀x Stunt\_Co-ordinator (x) → Crew\_Member(x) |
|  | ∀x Cinematographer (x) → Crew\_Member(x) |
|  | ∀x Camera\_Operator (x) → Crew\_Member(x) |
|  | ∀x Location\_Manager (x) → Crew\_Member(x) |
|  | ∀x Location\_Scout (x) → Crew\_Member(x) |
|  | ∀x Production\_Sound\_Mixer (x) → Crew\_Member(x) |
|  | ∀x Boom\_Operator (x) → Crew\_Member(x) |
|  | ∀x Set\_Designer (x) → Crew\_Member(x) |
|  | ∀x Buyer (x) → Crew\_Member(x) |
|  | ∀x Construction\_Crew (x) → Crew\_Member(x) |
|  | ∀x Gaffer (x) → Crew\_Member(x) |
|  | ∀x Lighting\_Technician (x) → Crew\_Member(x) |
|  | ∀x Makeup\_Artist (x) → Crew\_Member(x) |
|  | ∀x Hairdresser (x) → Crew\_Member(x) |
|  | ∀x VFX\_Supervisor (x) → Crew\_Member(x) |
|  | ∀x Costume\_Designer (x) → Crew\_Member(x) |
|  | ∀x Costume\_Supervisor (x) → Crew\_Member(x) |
|  | ∀x Film\_Editor (x) → Crew\_Member(x) |
|  | ∀x Storyboard\_Artist (x) → Crew\_Member(x) |
|  | ∀x Casting\_Director(x) → Crew\_Member(x) |
|  | ∀x Actor (x) → Crew\_Member(x) |
|  | ∀x (Producer(x) → ∃y supervisesProduction (x, y) Λ Film(y)) |
|  | ∀x (Director(x) → ∃y managesCreativeAspectOf (x, y) Λ Film(y)) |
|  | ∀x (Screenwriter(x) → ∃y creates (x, y) Λ Script(y)) |
|  | ∀x (Executive\_Producer(x) → ∃y investsIn (x, y) Λ Film(y)) |
|  | ∀x (Line\_Producer(x) → ∃y oversees (x, y) Λ Budget(y)) |
|  | ∀x (Production\_Co-ordinator(x) → ∃y, z hires (x, y) Λ rents (x, z) Λ Crew(y) Λ Equipment(z)) |
|  | ∀x (Story\_Producer(x) → ∃y creates (x, y) Λ Story(y)) |
|  | ∀x (Script\_Editor(x) → ∃y revises (x, y) Λ Script(y)) |
|  | ∀x (Stunt\_Co-ordinator(x) → ∃y supervisesStuntsOf (x, y) Λ Stunt\_Crew(y)) |
|  | ∀x (Cinematographer(x) → ∃y framesShotsFor (x, y) Λ Scene(y)) |
|  | ∀x (Camera\_Operator (x) → ∃y captures (x, y) Λ Scene(y) |
|  | ∀x (Location\_Manager(x) → ∃y managesLogisticsOf (x, y) Λ Location(y)) |
|  | ∀x (Location\_Scout(x) → ∃y searchesFor (x, y) Λ Location(y)) |
|  | ∀x (Production\_Sound\_Mixer(x) → ∃y managesSoundEngineeringOf (x, y) Λ Film(y)) |
|  | ∀x (Boom\_Operator(x) → ∃y operates(x,y) Λ Sound\_Equipment(y)) |
|  | ∀x (Set\_Designer(x) → ∃y designsLayout (x, y) Λ Set(y)) |
|  | ∀x (Buyer(x) → ∃y purchases (x, y) Λ Set\_Material(y)) |
|  | ∀x (Construction\_Crew (x) → ∃y constructs (x, y) ∧ Set(y)) |
|  | ∀x (Gaffer (x) → ∃y setsUpElectricalComponentsFor(x, y) ∧ Scene(y)) |
|  | ∀x (Lighting\_Technician (x) → ∃y setsUpLightingFor (x, y) ∧ Scene(y)) |
|  | ∀x (Makeup\_Artist (x) → ∃y performsMakeupOperationsOn (x, y) ∧ Actor(y)) |
|  | ∀x (Hairdresser (x) → ∃y performsStylingOperationsOn (x, y) ∧ Actor(y)) |
|  | ∀x (VFX\_Supervisor (x) → ∃y coordinatesVisualEffectsOf(x, y) ∧ Scene(y)) |
|  | ∀x (Costume\_Designer (x) → ∃y designsStyleOf (x, y) ∧ Costume(y)) |
|  | ∀x (Film\_Editor (x) → ∃y assembles (x, y) ∧ edits (x, y) Film(y)) |
|  | ∀x (Storyboard\_Artist (x) → ∃y makes (x, y) ∧ Storyboard(y)) |
|  | ∀x (Casting\_Director(x) → ∃y casts (x, y) Λ Actor(y)) |
|  | ∀x (Actor (x) → ∃y actsIn (x, y) ∧ Film(y)) |

## DL Representation of the Domain

|  |  |
| --- | --- |
|  | Film ⊆ hasStory.Story |
|  | Story ⊆ ∃ isBasedOn.Movie\_Idea |
|  | Script ⊆ ∃ depictsStory.Story |
|  | Book ⊆ Movie\_Idea |
|  | Book (Harry\_Potter\_and\_the\_Philosopher's\_Stone) |
|  | Play ⊆ Movie\_Idea |
|  | Play (Hamlet) |
|  | Another\_Film ⊆ Movie\_Idea |
|  | Another\_Film (Lion\_King) |
|  | True\_Story ⊆ Movie\_Idea |
|  | True\_Story (The\_Long\_Walk\_To\_Freedom) |
|  | Video\_Game ⊆ Movie\_Idea |
|  | Video\_Game (Tomb\_Raider) |
|  | Comic\_Book ⊆ Movie\_Idea |
|  | Comic\_Book (Batman\_:\_The\_Dark\_Knight) |
|  | Original\_Idea ⊆ Movie\_Idea |
|  | Film ⊆ ∃ filmIsAwardedWith.Award |
|  | Film ⊆ ∃ actorIsAwardedWith.Award |
|  | Award (BAFTA\_Film\_Award) |
|  | Award (Golden\_Globe\_Award) |
|  | Award (Oscar\_Award) |
|  | Film ⊆ ∃ madeUp.Scene |
|  | Scene ⊆ ∃ shotAtLocation.Location |
|  | Scene ⊆ ∃ hasSet.Set |
|  | Set ⊆ ∃ hasLocation.Location |
|  | Colour\_Info ⊆ Presentation |
|  | Colour\_Info (Black\_and\_White) |
|  | Colour\_Info (Colour) |
|  | Language ⊆ Presentation |
|  | Language (English) |
|  | Language (Spanish) |
|  | Film ⊆ ∃ hasReleasingCountry.Country |
|  | Film ⊆ ∃ hasRanking.Ranking |
|  | Film ⊆ ∃ hasRestriction.Restriction |
|  | Restriction (Content\_Restriction) |
|  | Restriction (Age\_Restriction) |
|  | Script ⊆ ∃ enactedIn.Scene |
|  | Actor ⊆ ∃ enacts.Script ⊓ ∃ inScene.Scene |
|  | Film ⊆ ∃ hasMonetary.Budget |
|  | Film\_Budget ⊆ Budget |
|  | Markeing\_Budget ⊆ Budget |
|  | Film\_Budget (Story\_Rights\_Cost) |
|  | Film\_Budget (Screenplay\_Cost) |
|  | Film\_Budget (Cast\_Cost) |
|  | Film\_Budget (Producer\_Cost) |
|  | Film\_Budget (Director\_Cost) |
|  | Film\_Budget (Production\_Cost) |
|  | Film\_Budget (Production\_Staff\_Cost) |
|  | Film\_Budget (Post\_Production\_Cost) |
|  | Film\_Budget (Insurance) |
|  | Film\_Budget (Completion\_Bond) |
|  | Marketing\_Budget (Third\_Party) |
|  | Film ⊆ ∃ marketedBy.PromotionTechnique |
|  | Promotion\_Technique (Cinema\_Trailer) |
|  | Promotion\_Technique (Movie\_Poster) |
|  | Promotion\_Technique (Online\_Advertisment) |
|  | Crew\_Member ⊆ ∃ utilizes.Equipment |
|  | Camera\_Equipment ⊆ Equipment |
|  | Lighting\_Equipment ⊆ Equipment |
|  | Sound\_Equipment ⊆ Equipment |
|  | Equipment (Screenwriting\_Software) |
|  | Equipment (Clapperboard) |
|  | Equipment (Storyboard\_Maker) |
|  | Camera\_ Equipment (Camera) |
|  | Camera\_ Equipment (Lens) |
|  | Camera\_ Equipment (Tripod) |
|  | Lighting\_Equipment (Light\_Meter) |
|  | Lighting\_Equipment (Light) |
|  | Sound\_Equipment (Microphone) |
|  | Sound\_Equipment (Boom\_Pole) |
|  | Film ⊆ ∃ isFinancedBy.Funding |
|  | Funding (Government\_Grant) |
|  | Funding (Tax\_Incentive) |
|  | Funding (Private\_Source) |
|  | Funding (Crowd\_Funding) |
|  | Funding (Studio\_Financing) |
|  | Funding (Pre\_Sales) |
|  | Set ⊆ ∃ createdFrom.Set\_Material |
|  | Set\_Material (Backdrop) |
|  | Set\_Material (Scenery) |
|  | Set\_Material (Prop) |
|  | Set\_Material (Flooring) |
|  | Set\_Material (Lighting) |
|  | Set\_Material (Scenery\_Wagon) |
|  | Set\_Material (Carpentry) |
|  | Film ⊓ produced ⊆ ∃ distributedBy.Distribution\_Technique |
|  | Distribution\_Technique (Theatrical\_Release) |
|  | Distribution\_Technique (Streaming\_Release) |
|  | Distribution\_Technique (Festival\_Release) |
|  | Film ⊆ ∃ belongsTo.Genre |
|  | Genre (Action\_Genre) |
|  | Genre (Comedy\_Genre) |
|  | Genre (Crime\_Genre) |
|  | Genre (Drama\_Genre) |
|  | Genre (Fantasy\_Genre) |
|  | Genre (Historical\_Genre) |
|  | Genre (Horror\_Genre) |
|  | Genre (Mystery\_Genre) |
|  | Genre (Political\_Genre) |
|  | Genre (Romance\_Genre) |
|  | Genre (Thriller\_Genre) |
|  | Producer ⊆ Crew\_Member |
|  | Director ⊆ Crew\_Member |
|  | Screenwriter ⊆ Crew\_Member |
|  | Executive\_Producer ⊆ Crew\_Member |
|  | Line\_Producer ⊆ Crew\_Member |
|  | Production\_Co-ordinator ⊆ Crew\_Member |
|  | Story\_Producer ⊆ Crew\_Member |
|  | Script\_Editor ⊆ Crew\_Member |
|  | Stunt\_Co-ordinator ⊆ Crew\_Member |
|  | Cinematographer ⊆ Crew\_Member |
|  | Camera\_Operator ⊆ Crew\_Member |
|  | Location\_Manager ⊆ Crew\_Member |
|  | Location\_Scout ⊆ Crew\_Member |
|  | Production\_Sound\_Mixer ⊆ Crew\_Member |
|  | Boom\_Operator ⊆ Crew\_Member |
|  | Set\_Designer ⊆ Crew\_Member |
|  | Buyer ⊆ Crew\_Member |
|  | Construction\_Crew ⊆ Crew\_Member |
|  | Gaffer ⊆ Crew\_Member |
|  | Lighting\_Technician ⊆ Crew\_Member |
|  | Makeup\_Artist ⊆ Crew\_Member |
|  | Hairdresser ⊆ Crew\_Member |
|  | VFX\_Supervisor ⊆ Crew\_Member |
|  | Costume\_Designer ⊆ Crew\_Member |
|  | Costume\_Supervisor ⊆ Crew\_Member |
|  | Film\_Editor ⊆ Crew\_Member |
|  | Storyboard\_Artist ⊆ Crew\_Member |
|  | Casting\_Director ⊆ Crew\_Member |
|  | Actor ⊆ Crew\_Member |
|  | Producer ⊆ ∃ supervisesProduction.Film |
|  | Director ⊆ ∃ managesCreativeAspectOf.Film |
|  | Screenwriter ⊆ ∃ createsScript.Script |
|  | Exceutive\_Producer ⊆ ∃ invests.Film |
|  | Line\_Producer ⊆ ∃ oversees.Budget |
|  | Production\_Co-ordinator ⊆ ∃ hires.Crew\_Member ⊓ ∃rents.Equipment |
|  | Story\_Producer⊆ ∃ createsStory.Story |
|  | Script\_Editor ⊆ ∃ revises.Script |
|  | Stunt\_Co-ordinator ⊆ ∃ supervisesStuntsOf.Stunt\_Crew |
|  | Cinematographer ⊆ ∃ framesShots.Scene |
|  | Camera\_Operator ⊆ ∃ captures.Scene |
|  | Location\_Manager ⊆ ∃ managesLogisticsOf.Location |
|  | Location\_Scout ⊆ ∃ searchesFor.Location |
|  | Production\_Sound\_Mixer ⊆ ∃ managesSoundEngineeringOf.Film |
|  | Boom\_Operator ⊆ ∃ operates.Sound\_Equipment |
|  | Set\_Designer ⊆ ∃ designsLayout .Set |
|  | Buyer ⊆ ∃ purchases.Set\_Material |
|  | Construction\_Crew⊆ ∃ constructs.Set |
|  | Gaffer ⊆ ∃ setsUpElectricalComponentsFor.Scene |
|  | Lighting\_Technician ⊆ ∃ setsUpLightingFor.Scene |
|  | Makeup\_Artist ⊆ ∃ performsMakeupOperationsOn.Actor |
|  | Hairdresser ⊆ ∃ performsStylingOperationsOn.Actor |
|  | VFX\_Supervisor ⊆ ∃ coordinatesVisualEffectsOf.Scene |
|  | Costume\_Designer ⊆ ∃ designsStyleOf.Costume |
|  | Film\_Editor ⊆ ∃ assembles.Film ⊓ ∃ edits.Film |
|  | Storyboard\_Artist ⊆ ∃ makes.Storyboard |
|  | Casting\_Director ⊆ ∃ casts.Actor |
|  | Actor ⊆ ∃ actsIn.Film |

# Experimental Results

## Dataset

This Ontology uses concepts from the MovieLabs White Paper [18] and the Film Crew Hierarchy Website[5]. The white paper provided us with the various classes used in a film ontology and the relationships they had whilst the Website gave us the list of all the crew Members needed to make a film.  The terminology was extended to fit the exact scope of our ontology and additional relations were added to adapt it to filmmaking.

## Computer and Software Environments

This ontology was created using Protege 5.5.0. It is an open source tool that allows users to make, edit and manage Ontologies and to represent with the aid of an intuitive GUI.

It also gives users the ability to visualise the relationships between structures and allows one to easily navigate those relationships.

The Ontology was modelled on a computer with the following specifications:

CPU: Ryzen 7 1700X

Ram: 16GB DDR4 2666Mhz

Storage: Samsung 500GB SSD

Operating System: Windows 10

## Results and Discussion

## The attached screenshots and Code Samples show an overview of the Devolped Ontology in Protégé. Please refer to section after Conclusion. The Images labelled “CLASSES” show every class present in the Ontology inluding sublasses. The sub classses of Crew\_Member represent the film crew. We could not model these as instances as they would be queried in the real world with the respective result being the Individual person in that role. An Example of this is would be if Netflix queried a director the instance of that would be “Michael Bay’ for example. This was applied elsewhere as well, i.e. we left things as classes if they would need to be queried and an individul would need to returned. All things that do not have to return individuals from queries have been designed as instances. An example of this would be”Camera” in the “INSTANCES” Images. If you queried Camera Eqipment it would return Camera but the actual make or model of the camera is not improtant to a film production ontology, just the fact that one was used. The ontology does a good job of representing a framework for film production. It includes essential classes and properties that can be used to standardize the film domain. As can be seen in “CLASS DESCRIPTION 1” we made some classes dijoint to show that they cannot share instances regardless of how they are interpreted, this makes domain knowledge explicit for the computer.

## The competency questions posed are answered in the Ontology from a production point of view as well as a film point of view. i.e. a user is able to query information for each step of film production an example would be a user querying budget and the return being all the aspects the budget needs to cover. The film aspect is covered in the sense that it automates the relation of information to other machines, the IMDB example is one such aspect. This ontology covers most aspects of a film from inception to distribution , so that if IMDB needed machine readable information on the actors and the awards they have gotten, it is available

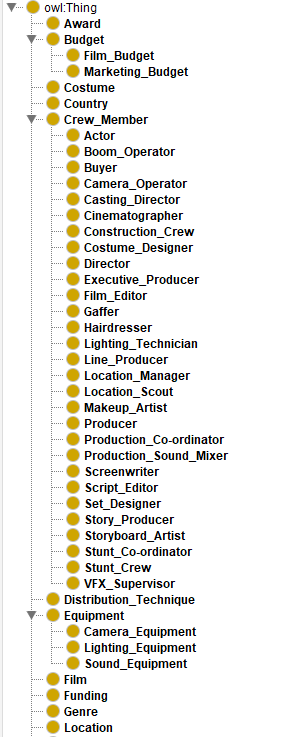
# Conclusion

The film-making ontology will assist film-makers by making the task at hand a much easier one to fulfil. Film-makers will now have a model to base future projects on that will guide their research and creative process.

Future additions to the model may include a number of expansions in specific aspects, for example, the equipment that is used in films are currently not all explicitly stated but it may be added. Budgets and funding may be expanded on as well.

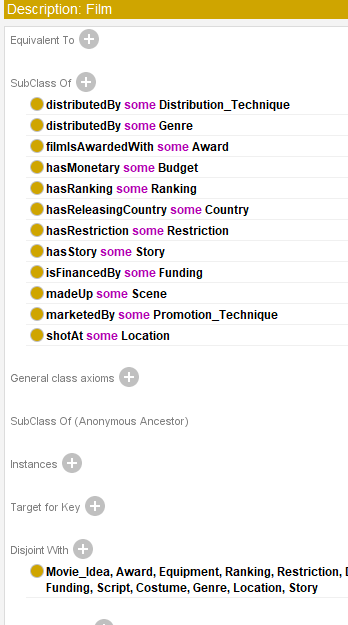
While the study assists with the film-making process, constant technological advances and new trends may see the need to grow this ontology. However, at present, this film-making ontology will make an excellent baseline on which film-makers can base their projects.

##### Classes 1/2



##### Classes 2/2

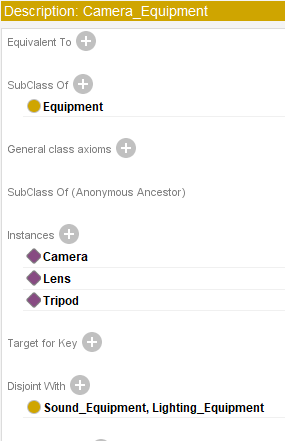


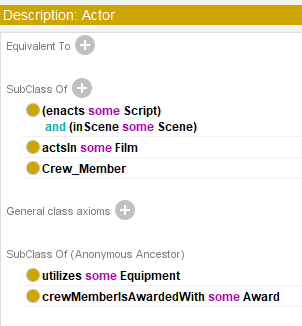


##### Class Description 1/3

##### 

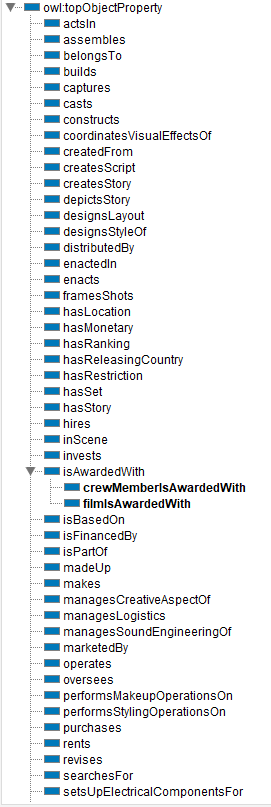
##### Class Description 2/3



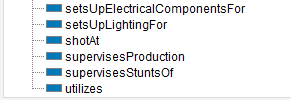


##### Class Description 3/3

##### Object Properties 1/2



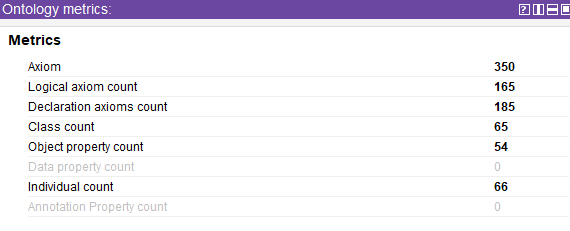
##### Object Property 2/2



##### Instances 2/2



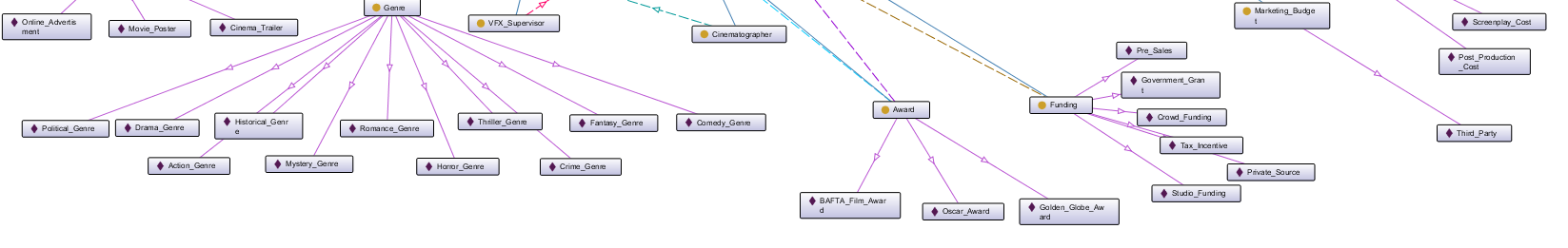
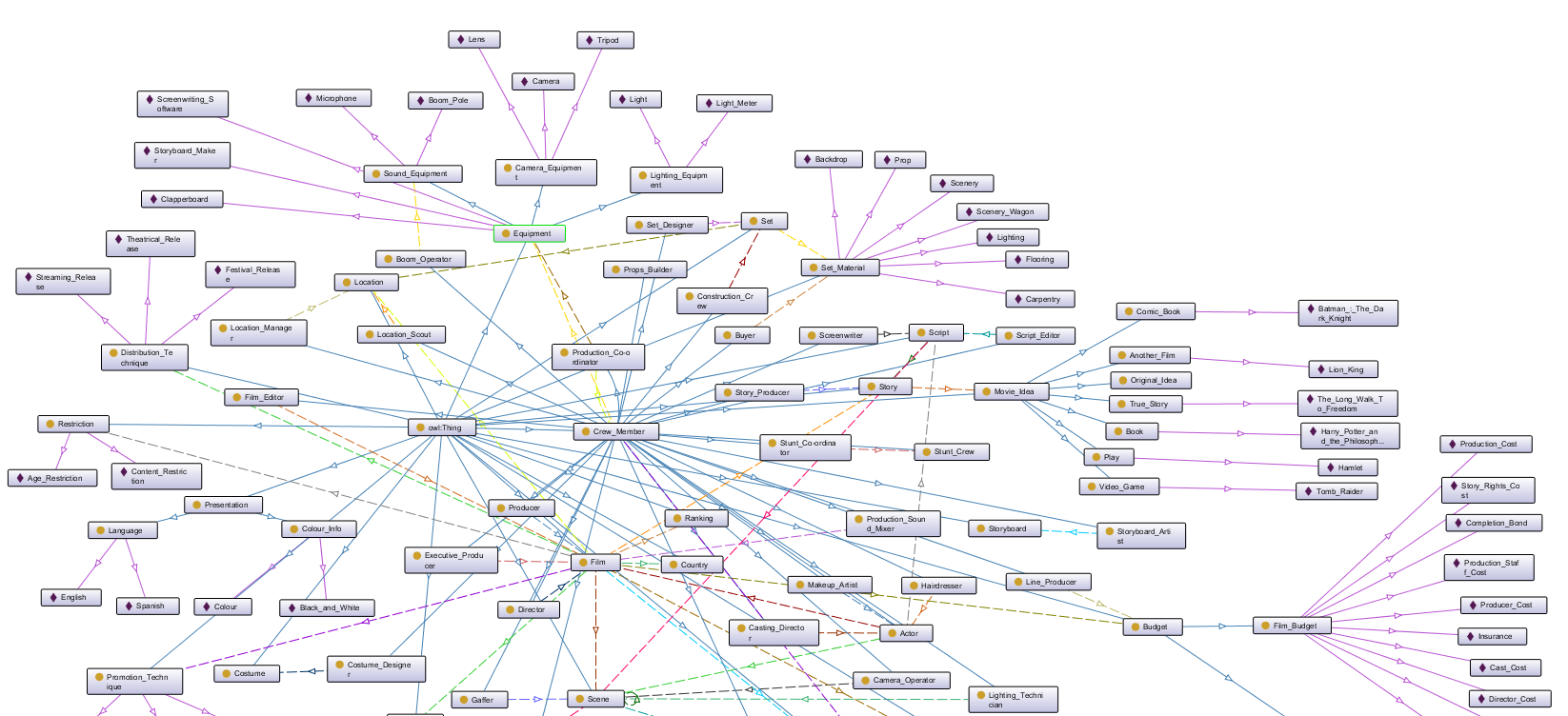
##### Metrics



##### Instance 1/2

##### 

##### Ontograf Conceptual view of Ontology



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